ABSTRACT

Gloria F. Putnam. Considerations for Developing a Comprehensive Closure Plan for Inactive Swine Waste Lagoons. (Under The Direction of Dr. DONALD E. FRANCISCO).

Environmental impacts and regulations in North Carolina related to closing unused swine waste lagoons were examined. There are over 3,000 swine operations in North Carolina, each raising more than 250 hogs, which use anaerobic waste lagoons to treat and store their waste. Most of the facilities in the state with populations of 1,000 or more hogs began operation after 1990. Environmental and public health risks, although not as yet quantified, are associated with anaerobic lagoons and until these impoundments are closed the risks remain. Four county health boards and one county commission in the state have adopted rules mandating lagoon closure of certain swine operations within their jurisdiction when the facility ceases production. Four of these counties also have bonding requirements to ensure funds for completing the closure. One hundred-two of the existing swine operations in the state are subject to these county provisions. All other swine operations in the state rasing more than 250 hogs are subject only to state requirements - which allow facilities that are going out of business to either close their lagoon or maintain it under a waste management plan. The North Carolina Agriculture Cost Share Program is the only program in the state which provides financial assistance for closing lagoons and is restricted to closing lagoons which are abandoned or located at operations going out of business. This program will not be able to fund closure of all inactive swine waste lagoons in the state. Based on the information reviewed, the state should develop a plan to address the issues related to closing unused lagoons. Specific items which deserve consideration include options for holding swine operations financial responsible for closure, evaluating current closure standards, refining cost-shared expenditures, and providing clear statutory authority for mandating lagoon closure.

TABLE OF CONTENTS

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LIST OF ACRONYMS

BMP	Best Management Practice
CCP	Comprehensive Closure Plan
DSWC	Division of Soil and Water Conservation
DWQ	Division of Water Quality
ILO	Intensive Livestock Operation
EMC	Environmental Management Commission
NCACSP	North Carolina Agriculture Cost Share Program
NCDA	North Carolina Department of Agriculture
NCDENR	North Carolina Department of Environment and Natural Resources
NCCES	North Carolina Cooperative Extension Service
NCGA	North Carolina General Assembly
NRCS	Natural Resources Conservation Service
SWCC	Soil and Water Conservation Commission
WMP	Waste Management Plan
WMS	Waste Management System
WUP	Waste Utilization Plan
USDA	United States Department of Agriculture

I. INTRODUCTION

Across North Carolina, anaerobic waste lagoons are used to treat animal waste at swine facilities. Many of these operations and their lagoons were constructed during the last seven years as the state's swine population grew from 2.8 million hogs in 1990 to 9.3 million hogs in 1996 (NCDA 1995b, NCDA 1997). This unprecedented growth occurred as a result of intensified production at new and expanding facilities. As individual operations have grown in size so have the capacities of the anaerobic waste lagoons serving them.

Since 1993 the state has continued to strengthen and improve its environmental regulations for animal waste lagoons as the environmental and public health concerns associated with anaerobic lagoons at these larger operations have become apparent. New and revised requirements have included more stringent provisions for the siting, design, construction, operation, and maintenance of animal waste lagoons. In response to public pressure and in an effort to provide time for assessing the impact of the state's swine industry and effectiveness of current regulations, the 1997 North Carolina General Assembly (NCGA) approved House Bill 515. This legislation contains, among many other provisions, a two-year moratorium, on new or expanded swine operations with populations of 250 more (S.L. 1997-458 Part I, Section 1.1(a)). The moratorium extends from March 1, 1997 to March 1, 1999.

Despite all of the attention paid to waste management at swine operations, little consideration has been given to the long-term management issue of closing lagoons which are no longer used (inactive). However, this is an issue that has been acknowledged as a concern by some regulatory agency staff members, a few environmental groups, and several local governments. It will become more of an issue in the near future as the North Carolina Department of Agriculture (NCDA) fulfills its mandate from the 1997 NCGA to develop a plan to phase out the use of anaerobic

lagoons as the primary form of waste treatment in the swine industry (Part XII, Section 12.6, House Bill 515, NCGA Regular Session).

This report focuses on the issues, regulations, and practices related to closing unused animal waste lagoons in North Carolina and offers recommendations for developing policies to address this environmental and public policy concern. Provided in the following Section is a brief history of the growth in North Carolina's swine industry and the geographic distribution of existing swine facilities. Section Three then explains how a lagoon functions and Section Four identifies the environmental and public health risks associated with these units. In Section Five, the state and county policies and authorities for closing animal waste lagoons are identified. Also included in this Section is a brief summary and analysis of government-assisted lagoon closures in North Carolina. Section Six identifies relevant legislation from other states, and closure policies in North Carolina for other storage/treatment units. A brief summary of research on new swine waste treatment technologies is provided in Section Seven. Finally, Section Eight contains a summary, conclusions, and recommendations. A list of acronyms is provided at the beginning of the report for the reader's convenience.

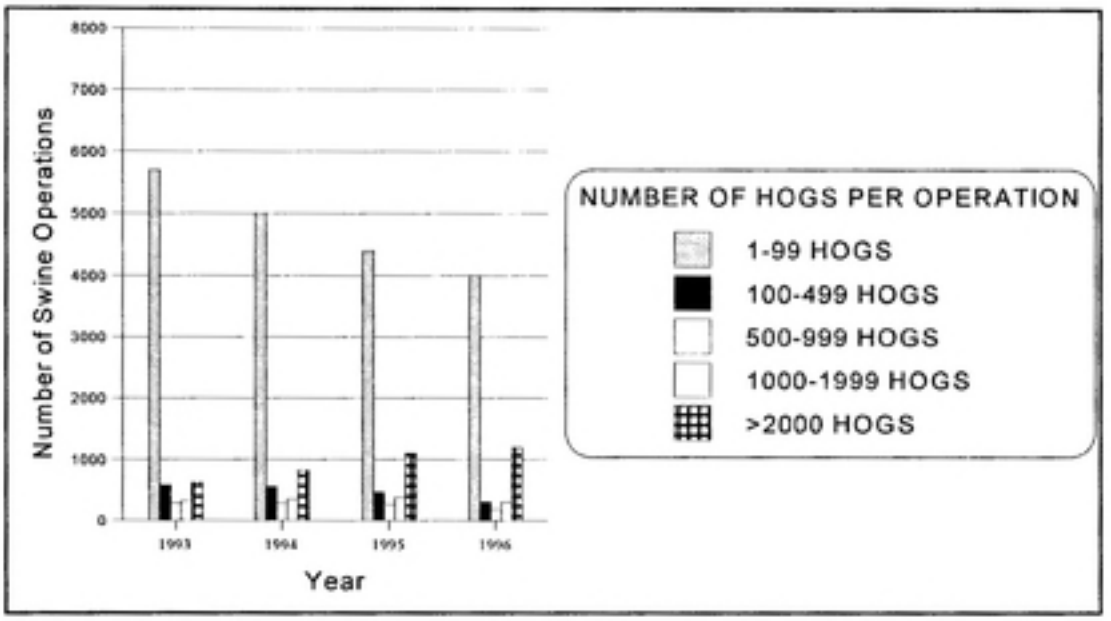
II. NORTH CAROLINA'S SWINE INDUSTRY

North Carolina's swine industry has experienced a fundamental change in its structure over the past decade as production has shifted from numerous small operations to fewer, larger, more specialized facilities. This change is reflected by the numbers in the two data sets presented in Figure 1 and Table 1.

As can be seen in Figure 1, most of the loss in total operations between 1993 and 1996 resulted from the reduction of 1,700 facilities that had hog populations of less than 100. Other losses included the reduction of 410 operations of the mid-size range (between 100 and 999 hogs) and the net loss of 20 operations with between 1000 and 1999 hogs. These losses were offset by an increase of 580 facilities which each raise more than 2,000 swine - creating a net loss of 1,500 operations. While data are not available to analyze expansion or downsizing that may have occurred between the size groups each year, it is clear from the data in Table 1 that the growth in larger sized facilities resulted primarily from new operations entering the industry rather than expansion of smaller facilities. This is evident because the smallest three size groups of operations experienced declines in each from 1994 to 1996 (inclusive), and therefore the facilities registering with the state for the first time between 1994 and 1996 had to be represented by the size groups with 1000 or more hogs.

Figure 1

Swine Operations in North Carolina By Size Group
1993 - 1996



Sources: NCDA 1995a, NCDA 1996, NCDA 1997.

Table 1

Number of New and Expanding Swine Operations
Meeting State Threshold Numbers
1993-1997

Year	Number of New Swine Facilities	Number of Expanding[1] Swine Facilities
1993	BASELINE[2]	2
1994	276	46
1995	325	49
1996	172	32
1997	45	13
TOTAL	818	142

[1]Expanding operations are defined in the .0200 Regulations as operations with waste treatment systems which require an increase over the existing animal waste design treatment and storage capacity due to an increase in animal population (15 NCAC 02H.200 Waste Not Discharged to Surface Waters .0203(15)).
These facilities were raising 250 or more hogsat the time of expansion.
[2]1993 was the first year facilities were required to register with the DWQ. This number was reported to be approximately 2500 and includes all operations that existed at that time (Sue Homewood Personal Communication August 12, 1997).
Sources: NCDENR 1997b, Sue Homewood Personal Communication August 12, 1997.

Production and marketing methods have also been modified as swine facilities have enlarged. At the large facilities, climate-controlled buildings rather than open feedlots are used to house or confine swine that have been genetically selected to grow quickly and produce lean meat with less feed (Barkema and Cook 1993). Additionally, disease is kept under control through extensive use of pharmaceuticals and diets (which often include a growth hormone) specifically formulated for producing lean hogs with minimal fat in a short time period (Barkema and Cook 1993). These larger operations, referred to generally as intensive animal operations, have also developed stronger and

more economically dependent ties with the factories which process their hogs. This relationship is either in the form of full ownership of the production facility by the processor (termed vertical integration) or as a contractual agreement between the processor and the grower (Barkema and Cook 1993). In a contractual agreement, the processor or contractor provides young pigs, feed, veterinary supplies, and management advice while the producer furnishes land, labor, buildings, and equipment (Barkema and Cook 1993). The result of these marketing and production changes is that the larger swine producers are yielding swine of a higher and more uniform quality than has traditionally been generated; economies of scale[1] are being realized; and markets for their hogs have been secured. In turn, this has placed many of the smaller producers at an economic disadvantage - forcing many of them from the trade. Change in the industry is evident by the distribution of the state's hog population - 92% of the state's 1996 hog inventory resided at facilities with populations of over 2,000 and an additional 5% was at facilities with populations of between 1,000 and 1,999 (NCDA 1997). The remaining hogs were distributed at the following facilities:

1.5% at facilities with 500-999 hogs,
1.0% at facilities with 100- 499 hogs, and
0.5% at facilities with 1-99 hogs.

Despite the trend in North Carolina's swine industry toward more intensive production, the method of waste treatment historically utilized by the industry has remained the same. This method begins with collecting animal waste in an open impoundment, referred to as a lagoon. Here the waste is stored and is anaerobically decomposed by microbes - microbes are naturally present in the excreted waste and accumulate in the lagoon as wastes are added. Decomposed wastes are later applied to

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[1] This is an economic term which indicates, among other concepts, that average production costs decrease as production increases.

crops - which is considered the final step of treatment. According to state records, in April of 1997 there were 3,001 swine operations rearing 250 or more hogs located in North Carolina using lagoons or storage ponds to treat their or store their waste (NCDEHNR 1997a).

Table 2 shows where these facilities are located in the state according to the Division of Water Quality (DWQ) Region[2] and identifies the number of DWQ personnel dedicated to animal waste inspections in each region (a complete listing of facilities by county is included in the Appendix). The total number of all registered animal operations which employ wet waste treatment systems[3] is also provided in Table 2 to allow a fuller perspective of the use of these systems throughout the animal production industry. As can be seen from these data, swine operations, and therefore lagoons, are highly concentrated in the eastern region of the state in the DWQ Regions of Fayetteville, Washington, and Wilmington.

2

There are seven regional DWQ offices in the state which have regulatory responsibility for counties in their region.

3

Wet waste systems treat or store waste which is primarily in liquid form and includes lagoons and storage ponds. Storage ponds do not treat waste but rather store it until it is land applied. Wet waste systems are used by all animal operations, including poultry, dairy, swine, and sheep operations. However, poultry operations more commonly use dry litter systems for waste treatment while dairy and sheep operations primarily use storage ponds for holding waste until it is land applied. With dry litter systems, an absorbent material such as straw or hay is placed on the production floor to collect waste. The litter is subsequently collected, composted, and then land applied.

Table 2

Total Number of Swine Operations, Animal Operations, and DWQ Inspectors In Each Division of Water Quality Region

North Carolina Location	DWQ REGION	ANIMAL OPERATIONS		NUMBER OF DWQ INSPECTORS[1]
		SWINE	*ALL*	
Central	Mooresville	53	232	1
Coastal	Wilmington	889	897	3
Mountains	Asheville	9	94	1
Coastal	Fayetteville	921	948	3
Central	Winston-Salem	54	219	1
Coastal	Washington	760	783	3
Central	Raleigh	315	462	2

[1] These are inspectors with the Division of Water Quality which perform the annual review of registered animal operations for permit.
Source: NCDEHNR 1997a, Sue Homewood Personal Communication August 12, 1997.

Although the 1997 NCGA adopted a two-year moratorium on new and expanding hog operations in North Carolina, some of North Carolina's largest pork producers may not be adversely impacted by this restriction because they are expanding their businesses to other states. In August of 1997, the Raleigh News and Observer reported that the largest hog farm in the United States is being planned through a joint venture of four of North Carolina's major hog producers, including Smithfield Foods, Murphy Family Farms, Carroll's Foods, and Prestage Farms (Raleigh News and Observer 1997). The planned facility is located in Beaver County, Utah and when completed is to be composed of 120 separate production units, each raising between 4,800 to 12,000 hogs per year

(Raleigh News and Observer 1997). Total annual production at this site is estimated to be approximately two million hogs (Williams 1997). Waste from the facility is to be treated using the traditional anaerobic lagoon system (Raleigh News and Observer 1997). In July of 1997, a Jacksonville, North Carolina daily newspaper also reported that Murphy Family Farms had initiated efforts to place a 42,000-head swine operation in Hodgeman County, Kansas (Jacksonville Daily News 1997). Other states where North Carolina pork producers are reported to be expanding include Oklahoma, Missouri, Illinois, and Colorado (Raleigh News and Observer 1997).

III. LAGOONS AND WASTE MANAGEMENT SYSTEMS

Animal waste lagoons are impoundments which provide the first step of treatment in a waste management system (WMS). Lagoons are designed, operated, and maintained for providing passive biological treatment (decomposition occurs as a result of naturally occurring anaerobic bacteria in the waste) and temporary storage of animal waste. Wastes are periodically removed and land applied for final "treatment". Production wastes must be transported to the lagoon from the area where the animals are confined. In smaller operations, a water hose is typically used to flush wastes into the impoundment from an impervious pad where the hogs are confined. Larger operations generally raise their hogs above a manure collection system on slotted floors so that feces and urine fall into a collection system[4] which is connected to the lagoon.

An established anaerobic lagoon functions in the following manner. After production waste is transported and placed in the impoundment, the solid materials slowly settle out, leaving a surface layer of liquid (supernatant) containing dissolved material and fine-particle solids (Hobson and Robertson 1977). Throughout the lagoon, wastes are decomposed by various forms of microbes, each using the metabolic byproducts of others. Aerobic microbes occur in the top few inches of the liquid and convert dissolved waste within this oxygenated zone into carbon dioxide and water. Below this surface layer, oxygen levels decrease with depth and anaerobic bacteria increase. Eventually all decomposition is anaerobic and therefore much of the waste within this zone is converted to acids and gases (hydrogen, carbon dioxide, methane, hydrogen sulfide and ammonia). Towards the bottom of the lagoon, byproducts from anaerobic processes may accumulate and kill off the microbes which produce them if they

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[4] These collection systems may be of the following type: a deep pit (usually 6-10 feet deep), a gutter or gravity drain (18-24 inches deep), an area that is mechanically scraped (10-24 inches deep), a flushing system (8-24 inches deep), or a pit recharge (32-36 inches deep) (NCCES 1992).

diffuse too slowly or if the microbes which utilize these byproducts are not present in high enough numbers to readily utilize the byproducts. Decomposition in this area is often very slow and at the very bottom of the lagoon, especially in the lower levels of the accumulated solids which contain the slowly biodegradable organic compounds such as lignin and cellulose, there is generally no microbial activity.

As expected, lagoons contain primarily animal excreta. This is composed of food residues, sloughed-off cells from the intestinal wall, intestinal bacteria, and urine - which contains salt and nitrogenous compounds (Hobson and Robertson 1977). In addition to the excreta, lagoons may contain other components which are washed into the basin including detergents and disinfectants used to clean equipment; antibiotics, antiparisitics, and other pharmaceuticals given to animals; and substances used for insect and aquatic weed control at the lagoon site (Hobson and Robertson 1977). If the concentration of these substances is high enough, it will affect the functioning of the lagoon by adversely altering microbial populations.

Periodically, supernatant and sludge must be removed to increase available storage and treatment space and to maintain the efficiency of the lagoon. Accumulation of both these materials varies with management, environment, waste characteristics, and loading rate (MPS 1985). Decomposition rates will depend on factors such as loading rates, waste contents, and environmental conditions such as temperature and rainfall. Although it is hard to generalize about required holding time for fresh wastes, a minimum of three months residence time is usually required before even a modest amount of anaerobic decomposition is to occur (Hobson and Robertson 1977). Lagoons constructed after February 1, 1996 have been required, under standards developed by the Natural Resource Conservation Service (NRCS), to include storage space for accommodating five years of sludge accumulation (NCDEHNR 1996)

Both the supernatant and sludge are land applied to provide final "treatment." Land application allows additional breakdown of wastes by soil microbes and uptake of

waste components by planted crops. When plants are harvested, the "wastes" are removed from the land. At operations with greater than 250 swine, wastes are required to be applied at agronomic rates - a rate which meets but does not exceed a specific plant's nutrient need. In North Carolina, agronomic rates for animal waste application are based on nitrogen (NCGS 143-215.10C(e)(6)). To determine the exact rate of animal waste to be applied, three factors must be considered. First, the amount of nitrogen that will be utilized or taken up from the soil by the crop that is grown must be estimated (NCCES 1995a). This will depend on the nitrogen requirements of the crop and the amount of plant growth which can be expected (Realistic Yield Expectation or RYE). Second, the amount of nitrogen already in the soil and is available for plant uptake must be measured. This is generally accomplished through soil tests. Third, the concentration of nitrogen in the waste must be determined. If wastes are repeatedly applied in excess of what a crop can remove, based on the above factors, nutrients will accumulate in the soil to levels which may inhibit plant growth (e.g. by altering soil pH levels) and unused concentrations of water soluble nutrients, such as nitrate,[5] will be transported with the flow of water during rain events. Even when agronomic rates are followed, there will be high levels of nitrogen accumulated in plant tissues. This will yield crops which have little or no economic value as feed, as this nutrient is toxic to livestock at high levels. However, this is likely of little concern for large producers using spray irrigation as a final form of treatment for waste. Crops are generally not selected for their wholesale value but for their ability to take up nitrogen - the higher the rate of uptake the more waste which can be land applied. Bermuda grass, which also has little economic value, is

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Nitrates enter groundwater through the following process. Bacteria present in the soil decompose organic materials containing nitrogen which have seeped from the lagoon. During this process, ammonia (NH_3) and ammonium (NH_4^+) are released and are then oxidized by bacteria of the genus Nitrosomonas into nitrite (NO_2^-) and then into nitrate (NO_3^-) by bacteria of the genus Nitrobacter (Curtis 1979). Nitrate, being highly water soluble, is transported through the soil matrix and into the surrounding groundwater.

commonly used in the industry because of its ability to take up large amounts of nitrogen. Note that disposal of harvested crops is not a regulated activity.

Nutrients in supernatant and sludge consist primarily of ammonium, phosphorus, and potassium (NCCES 1995b). Other nutrients present in smaller amounts include calcium, magnesium, sulfur, sodium, iron, manganese, boron, molybdenum, zinc, and copper. The heavy metals zinc and copper are more concentrated in the sludge than in the supernatant and originate in the swine feed (Hansen 1997). Zinc is a trace element and copper is both a trace element and a growth stimulant. Levels of zinc and copper are required to be monitored, by statute, and alternative crop sites are to be used if these metals approach "excess levels" (NCGS 143-215.10C(e)(6)). The term "excess levels" however is not defined.

Parasites and pathogens may also be found in wastes which are land-applied (PWRC 1984). As there is little heat produced in the lagoon, pathogens and parasites in the animal excreta survive longer in a lagoon than in other systems such as composting, which is a heat-producing treatment process (PWRC 1984). However, most of these parasites and pathogens are considered to be inactivated or destroyed when manure is spread on land.

Although it is typical for only a single lagoon to be used for waste treatment, some operations utilize a two-stage system consisting of two lagoons. With these lagoon systems, the first impoundment is used as a settling basin and for treatment of waste (MPS 1985) and is managed like a single stage lagoon. The second impoundment is used to hold liquids which are removed from the first lagoon. These liquids can be land applied or used for flushing production wastes from the collection system into the first lagoon (MPS 1985).

The three major factors that determine an appropriate lagoon size for a swine facility are the number and age of animals which will be raised at the facility; the volume of additional fluids like wash water and precipitation anticipated to be added to the

lagoon; and the amount of storage space required, based on projected liquid removal for land application. A general estimate for needed lagoon capacity is 0.3 cubic feet for each pig weighing 125-lbs (Hobson and Robertson 1977).

Using the available data for lagoon capacity and number of lagoons at 352 registered swine operations in North Carolina,[6] a profile of lagoons utilized at swine facilities was created (Figure 2). From this data it is seen that 75%, or 265, of these operations have one lagoon at the facility for treating waste. Of the remaining operations, 59 have two lagoons, 16 have three lagoons, and 8 have four lagoons (four operations did not have number of lagoons listed). These numbers concur with those in a study conducted by the North Carolina Cooperative Extension Service (1995b) which showed that three-quarters of the swine operations which use lagoons for waste treatment in this state have a one-stage system (the remaining operations have a two-stage system). Note that the presence of multiple lagoons at a facility does not indicate that it is part of a two-stage lagoon system, as many facilities use several single stage lagoons to meet their waste treatment needs. Some of the lagoons may also be older units that could not be retrofitted[7] to meet the more stringent lagoon design standards required in regulations that were adopted in 1993.

Figure 2 shows both the total lagoon capacity at each of the facilities and the lagoon capacity for facilities with only one lagoon. As can be seen, total lagoon capacity at the facilities ranges from 21,000 to 5,395,890 cubic feet. For reference, a room measuring 12 foot by 12 foot with a 10 foot ceiling has a volume of 1,440 cubic feet. The smallest lagoon in the data set would therefore hold just over 15 "rooms" full of waste materials and the largest lagoon would hold 3,747 "rooms".

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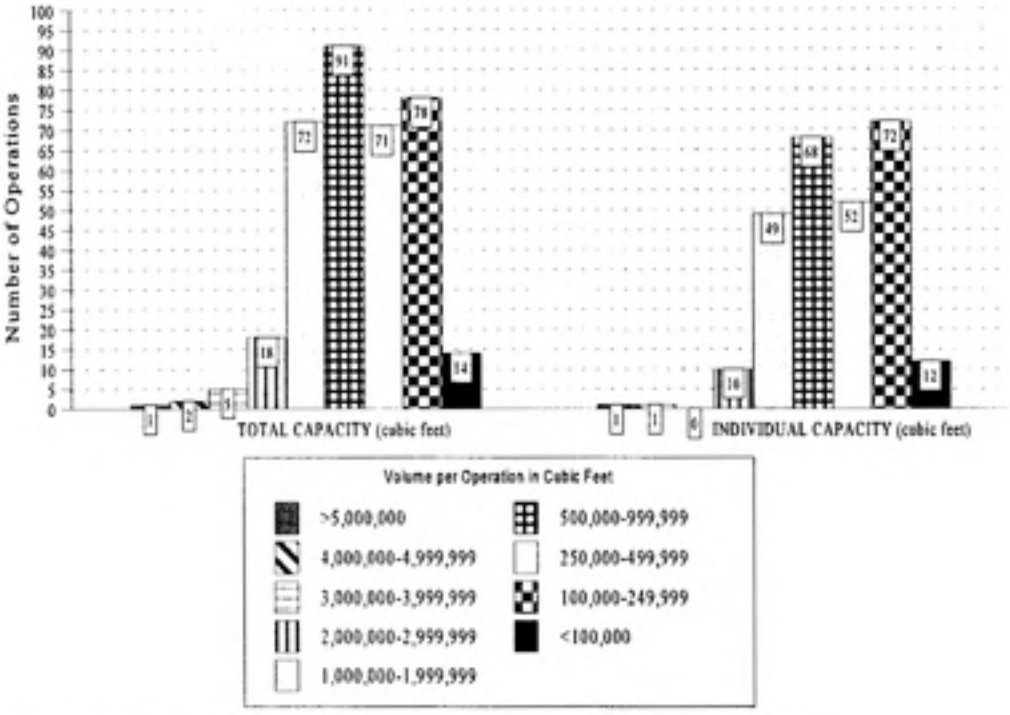
6 Lagoon capacity data was only available for these operations and was reported as a total amount, even at facilities where more than one lagoon was used.

7 Retrofitting entails a modification to the lagoon to either increase storage or correct a design flaw.

Lagoon designs are of three common types: in ground (with no dikes), above ground and diked on all sides, or above ground and partially diked (built into a slope where the excavated material is used to build the dike) (Huffman and Westerman 1995). Liners, generally composed of clay, have only recently been included in the design of lagoons as a means of preventing or controlling seepage to protect groundwater resources. The absence of a lagoon liner requirement has been based on the determination that unlined animal waste lagoons undergo a process of "self-sealing", where bacterial cells and fine organic matter from the animal waste clog soil pores along the bottom and sides of the impoundment (Sweeten 1993). However, pockets of permeable soils may exist in the lagoon through which wastes may leak despite "natural sealing." NRCS standards recognize the potential for groundwater contamination (Huffman and Westerman 1995) and since 1994, their lagoon design standards have required that liners be used in coarse soils to limit seepage losses.

Figure 2

Total Lagoon Capacity[1] and Capacity at Facilities with One Lagoon[2] Based on Available Data from 352 Swine Operations in North Carolina (March 1997)



[1] Total capacity represents the capacity of all waste lagoons at a facility (n=352).
[2] Individual capacity numbers represent the capacity at facilities with only one lagoon (n=265).
Source: NCDEHNR 1997a

IV. ENVIRONMENTAL AND HUMAN HEALTH CONSIDERATIONS

Swine waste lagoons may adversely affect several environmental media, and although there has been no direct research on the impacts of unused or abandoned lagoons, it is reasonable to assume that while waste materials remain in the impoundment, the associated environmental risks will still exist. The same will be true for human health affects, although in both cases, the characteristics of the risks may change over time. These environmental and human health effects of lagoons are discussed in this section and are divided according to the environmental medium in which the contamination occurs. Potential changes in these risks for unused or abandoned lagoons are discussed at the end of the section.

Environmental impacts associated with lagoons occur as a result of wastes leaving the impoundment through three routes. The first path of waste loss is through seepage from the lagoon into the surrounding soil matrix. Six recent studies (three of which are discussed here) show that swine lagoons, both with and without liners, leak wastes (see Table 4 at the end of this section for a brief summary of study results). This seepage occurs through various paths including, pockets of permeable soil which do not develop a "natural seal"; tunnels made by burrowing animals (Ciravolo 1979); cracks in clay liners (Ritter and Chirnside 1990)[8]; and disruption in the "natural seal" due to either drying of the embankment soil or gas which is released from microbial activity in the soil beneath the seal (Ciravolo 1979).

An estimate of the extent of seepage from unlined lagoons (no such study exists for lined lagoons) is provided in a study conducted by Huffman and Westerman (1995). The study contained eleven sites in North Carolina aged 10 to 20 years. These sites were

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[8] Ritter and Chirnside's (1990) study of clay-lined lagoons in Delaware's Delmarva Peninsula showed that the most severe groundwater contamination occurred at a lagoon which was completely emptied twice a year. The authors concluded that lagoons should not be pumped below design level in order to protect the clay from drying out and cracking, which would cause seepage of lagoon contents.

selected to represent the three major soil types in the most densely swine populated areas of North Carolina. Additionally, older unlined lagoons were chosen to assure that natural "sealing" had completely developed. Results of the study showed that estimated seepage from the studied lagoons was minimal for 5 of the systems and moderate to severe for the remaining sites. The authors state that if the results of the study are representative of the regions sampled, it can be concluded "that about half of the older unlined swine lagoons in the lower coastal plain of North Carolina are inadvertently contributing to local contamination of the surficial aquifer" (Huffman and Westerman 1995). Huffman and Westerman further explain that although contaminant concentrations in the seepage are far above water quality standards, small amounts of seepage can be assimilated by soil microbes or diluted to harmless concentrations once in the groundwater. Therefore, the extent of groundwater contamination in an area will depend on the rate and duration of seepage, the concentration of contaminants in the seepage, and the natural flow of groundwater in an area.

Waste which is not assimilated after it leaks into the soil may enter the shallow groundwater (surficial aquifer). Groundwater flow will then determine whether the waste remains in the surficial aquifer in the vicinity of the lagoon or discharged into a surface body of water, such as a stream or river (Huffman and Westerman 1995). The subsequent impacts on both groundwater and surface water will be influenced not only by the concentration of wastes in the inflowing groundwater but on the condition of the receiving water body (i.e. background level of other pollutants introduced in the system).

The primary contaminants associated with waste seepage are nitrate,[9] ammonia, and pathogenic organisms such as bacteria (Sweeten 1993). However, other constituents (potassium, sodium, chloride, and sulfate) may also leach and contaminate water. High

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[9] Nitrates enter groundwater through the following process. Bacteria present in the soil decompose the organic materials containing nitrogen which have seeped from the lagoon. During this process, ammonia (NH_3) and ammonium (NH_4^+) are released and are then oxidized by bacteria of the genus Nitrosomonas into nitrite (NO_2^-) and then into nitrate (NO_3^-) by bacteria of the genus Nitrobacter (Curtis 1979). Nitrate, being highly water soluble, may be transported through the soil matrix and into the surrounding groundwater.

levels of the primary pollutants (bacteria and nitrate) in drinking water supplies can result in negative impacts to human health. Nitrate contamination has been associated with the blood disorder methemoglobinemia. Primarily affecting fetuses and infants, this disorder is commonly referred to as "blue baby syndrome". The disorder occurs as a result of ingested nitrates being converted to nitrites in the upper areas of the gastrointestinal tract (Winneberger 1982). Nitrites are then absorbed into the bloodstream and combine with oxygen-carrying hemoglobin, forming methemoglobin (MetHb). When MetHb levels increase, oxygen levels in the bloodstream decrease (Winneberger 1982), and may result in asphyxiation at the cell level (El-Ahraf 1996). This disorder occurs most commonly in infants because conditions in the gastrointestinal tract enable nitrite-forming bacteria, found in the lower portion of the intestines, to migrate up the gastrointestinal tract (Winneberger 1982). In adults, nitrite-forming bacteria are not usually found in the upper areas of the gastrointestinal tract and nitrates are harmlessly absorbed into the bloodstream before they reach the lower portion of the intestines. As a prevention to this disorder (the extent of which is unknown), the U.S. Public Health Service has established an advisory level for nitrate/nitrogen concentration of 10 ppm in water supplies (USEPA 1979). Other possible health risks of ingesting high concentrations of nitrates may be esophageal and stomach cancer (NCCES 1993).

In addition to the human health effects listed above, groundwater contaminated with nitrates may also negatively effect the quality of surface waters to which it drains (rivers, estuaries, and lakes). In bodies of water which are nutrient sensitive,[10] addition of nitrogen will contribute to eutrophic conditions, contributing to nuisance algal blooms, hypoxic/anoxic conditions[11], fish kills, and alterations of food web structures (NCDEM

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10 This is a Supplemental Water Quality Classification used by the EMC to designate that nutrient management measures are needed because waters have an overabundance of phosphorous or nitrogen and are therefore experiencing or are subject to excessive growth of microscopic or macroscopic vegetation (15A NCAC 02B .0214(a)).

11 Decomposition of algae following a bloom episode consumes high levels of oxygen and may result in hypoxic (<2mg/L O_2) or anoxic (<.02mg/L O_2) water conditions.

1994). Problems at the swine farms may not be apparent but may become evident in a downstream impoundment such as a "sluggish creek" or estuary (NCDEM 1994).

Recent research also points to an association between nutrient rich waters and the toxic dinoflagellate *Pfiesteria piscicida* (Burkholder and Glasglow 1997). Pfisteria is a one-celled microogranism that has a complex life cycle. In one of its life stages, the organism emits a toxin which at high levels is lethal to finfish and shellfish and at low levels can cause ulcerative diseases in finfish. The organism has been identified in association with fish kills in North Carolina's Albemarle-Pamlico and Neuse Estuaries, and has also been found in Maryland's Pocomoke River (Burkholder and Glasglow 1997) and the Chesapeake Bay (Lewitus et al. 1995). *P. piscicidia's* toxin also poses health risks to humans. Among the effects of exposure to the toxin are epidermal lesions, respiratory distress, and short-term memory loss (Burkholder and Glasglow 1997). Exposure can be from direct contact of water containing the toxin or from volatilization of the compound. Fishermen, due to the nature of their occupation, are members of the population most susceptible to toxin exposure.

The impacts of nitrates on any receiving water body will depend partially on background levels of nitrogen and other common sources of nitrates such as septic tanks, fertilized fields and lawns, and other livestock operations. Due to the complexities of groundwater systems and the different paths which nitrogen can follow, it is difficult to trace in the environment or estimate groundwater nitrate concentrations on either a national or state level with any certainty (Hallberg 1989). What has been observed, however, is that natural background levels of nitrate in shallow groundwater tend to be less that 2 mg/L NO_3-N, and in agricultural areas these levels are often greater than 10 mg/L (Hallberg 1989). In a 1995 report (Mueller et al.) by the United States Geological Survey (USGS), study results of 12,000 water quality samples taken nationwide between 1979 and 1990 showed that the highest concentrations of nitrates in groundwater occur in the following areas: the northeastern United States, where intensive livestock facilities and other agricultural operations are located within dense rural populations; the intensely farmed area of the central United States grain-belt; and some of the irrigated agricultural

regions of California and Texas. The lowest groundwater nitrate concentrations were generally found in parts of the Southeast and the highest concentrations were in areas with intensive cultivation of row crops (Mueller et al. 1995). Data also showed that in 12 percent of the domestic water supply samples taken from agricultural areas, nitrate concentrations exceed the U.S. Environmental Protection Agency's drinking water quality standard for that substance (Mueller et al. 1995). The applicability of this data to North Carolina may be limited because the data set used was for water quality samples taken in or before 1990, which is prior to the growth in North Carolina's intensive swine industry.

For streams, nitrate loads have increased across the United States from the grain-belt eastward since 1974 despite a decrease in point source nitrogen loads (Hallberg 1989). In North Carolina, four river basins contain waters which have received a nutrient sensitive classification. The total number of river miles with this designation is 9,296, and includes the entire Tar-Pamlico River (2,246 miles), and portions of the Cape Fear (2,186 miles), Neuse (3,300 miles), and Chowan (1,564 miles) (Jason Doll Personal Communication October 21, 1997). The contribution of agriculture to nutrient loading of North Carolina streams has only been calculated for one of the state's seventeen river basins. This load was for the Tar-Pamlico River Basin and the estimated contribution of nitrogen was approximately 44% of total nitrogen received by the river (NCDEM 1994). The estimate for the percentage of this contribution from swine lagoons or animal operations was not calculated.

The second path for lagoon wastes to enter the environment is through volatilized compounds, which are released into the air as a result of the primary purpose of a lagoon - anaerobic and aerobic metabolism of production wastes. The fate of these substances will largely depend on the direction and intensity of wind. Human exposure and therefore health impacts will depend on proximity to the lagoon, barriers between the lagoon and the individual, and concentration of the emissions.

Methane is a major volatilized emission from a swine waste lagoon. It is recognized as a greenhouse gas and is therefore considered a contributor to global

warming (USDE 1996). Estimates of 1992 methane production in the U.S. from animal waste was 2.76 million metric tons. This represents approximately 9% of the total 26.6 million metric tons of methane produced in the U.S. that year (total global emissions in 1992 were 300-450 million metric tons).

Research of health issues associated with exposure to gases and odors has not focused exclusively on those which are emitted from lagoons. Studies also include emissions from the confinement area and land which is being irrigated with lagoon wastes, both of which are significant sources of gases and dust. Many of the identified human health impacts from animal operations therefore are associated with the entire operation rather than exclusively with the lagoon. With that in mind the following health effects are identified in association with discharged gases.

Hydrogen sulfide, ammonia, and volatilized fatty acids have direct impacts on human health. Hydrogen sulfide is a colorless, poisonous gas (USDE 1994). It is easily detected because it has the smell of rotten eggs but is considered an "insidious poison" because a human's sense of smell rapidly fatigues after initial exposure to this odor, to the point where it is no longer noticed. Exposure is generally through inhalation. At low concentrations (<10 parts per million (ppm)) it can cause irritation of the eyes, mucous membranes, and upper respiratory tract (USDE 1994). At concentrations between 10-50 ppm, a person may have mild eye and upper respiratory irritation, headaches, and dizziness. At higher levels (50-200 ppm), eye and respiratory tract irritation can be severe, and may also result in acute conjunctivitis, breathing difficulty, and sudden loss of consciousness.

Ammonia is similarly dangerous but the odor does not fatigue the smell and will cause a person to reduce exposure, if possible (El-Ahraf 1996) . It is estimated that most of the nitrogen that is removed from the supernatant while in the lagoon (approximately 80%) (MPS 1985) is released to the atmosphere in the form of ammonia (El-Ahraf 1996, Overcash 1983). Both ammonia and hydrogen sulfide have been shown to cause chronic health problems if exposure is prolonged, including decreased disease resistance, hemophilic tendencies, decreased maturation, back curvature, and hoof alterations in

other animals (El-Ahraf 1996). Four types of respiratory tract problems have been shown to be higher in residents living within a two-mile radius of a 4,000 swine production facility in comparison to individuals not living near the facility (Thu et al. 1997). The same types of problems have been documented in workers at a confinement facility. The cause of these problems in both populations may be due to inhalation of other air pollutants associated with swine production and therefore cannot be attributed exclusively to lagoon emissions.

As noted, hydrogen sulfide and volatilized ammonia are offensive to some individuals. However the most offensive odor results from volatile fatty acids (El-Ahraf 1996). Response to odors emitted from animal production facilities is very different with every individual because olfactory response is individualized (Schiffman et al. 1996). Responses often depend on items such as previous experiences with the odor, personal preferences, and sensitivities.

The third path of waste transport from lagoons is through discharges over banks of the waste lagoon. Overflows of lagoon contents occur as a result of poorly managed lagoon levels, heavy rain events, or a reduction in the integrity of a lagoon wall. The fate of spilled waste depends on many factors including amount of overflow; weather and soil conditions at time of overflow; local topography; concentration of contaminants in the lagoon spill; and location of the lagoon relative to ground or surface waters. The environmental impacts of these spills on groundwater will be of the same nature as those associated with seepage of waste, as bacteria and nitrates will travel down through the soil. For surface waters, nutrient loading and bacterial contamination will be of concern if spilled wastes enter the surface water directly.

Human health impacts of these wastes will depend on time of exposure, content of waste, physical condition of the person, and nature of exposure. Exposure may occur soon after the spill as the wastewater flows downstream (waste plume) or at some later time through contact of materials which have settled in the top layer of the river or stream sediment. In either case, the contaminants of concern would be pathogens (disease producing micro-organisms), bacteria, viruses, and parasites.

Risks for Discontinued and Abandoned Lagoons

The nature of the environmental impacts associated with discontinued and abandoned lagoons will be the same as those of functioning lagoons, particularly during the initial period when wastes are no longer received. Over time the degree of risks associated with the different paths of waste loss will be altered. Impacts associated with emissions will continue but will eventually decrease as the waste contained in the lagoon has been largely decomposed and the amount of volatile compounds escaping from the surface of the lagoon diminishes. The time it takes to reach this stabilized point will depend on many factors including the amount of "fresh" wastes and sludge within the lagoon, management of the lagoon, and environmental conditions such as temperature and rainfall. Second, any seepage from the lagoon will continue but the concentration of wastes in the seepage will decrease as a result of decomposition and dilution (from rainfall or water added for maintenance, especially of clay lined lagoons to prevent cracking). A third change will be a decrease in impacts of spills because lagoon wastes are more dilute. However, there may be an increase in the risks of spills if the integrity of the lagoons is compromised, such as wall strength or clay lining.

Two additional issues may be of concern with unused lagoons, both of which focus on liability. Environmental contamination, particularly that of soil or water, may be an issue of liability for a landowner. However, the liability of farm operations for groundwater contamination has not yet been determined through state courts. The second liability issue is that which may be associated with risks posed to anyone who accidentally or intentionally enters the impoundment.

Table 4

Summary of Recent Studies On
Swine Waste Lagoon Seepage

STUDY	LOCATION AND RESULTS
Ritter and Chirnside (1990) (Cited in text)	Delmarva Peninsula, Delaware - Clay lined animal waste lagoons located in sandy loam or loamy sand soils with high water tables may lead to degradation of groundwater quality.
Huffman and Westerman (1995) (Cited in Text)	Coastal Plain of North Carolina - Of the eleven lagoons in the study, estimated seepage at lagoons was low at five, moderately high at four, and severe at two.
Ciravolo et al. (1979) (Cited in Text)	Coastal Plain of Virginia - Of the three lagoons studied, 2 unlined anaerobic lagoons caused minimum groundwater contamination and 1 lined lagoon caused contamination in excess of drinking water standards for Cl and NO_3-N. The authors noted that tunneling by animal could cause pollution of groundwater.
Hegg (1979)	Coastal Plain of South Carolina - Most wells located near three recently installed lagoons showed no evidence of pollution after two years of monitoring, although a few showed rising levels. Leakage appeared to take place at specific points in the lagoon, indicating to the authors the importance of the location of monitoring wells in detecting seepage.
Ritter et al. (1984)	Delmarva Peninsula, Delaware - An unlined animal waste lagoon studied for four years resulted in increased concentrations of chloride, NH_3-N and NO_3-N and that a reduction of seepage had occurred over time. The authors concluded the following: lagoons installed in coarse-textured soils with high water tables will have some impact on groundwater; the lagoon in the study did not have a serious impact on groundwater quality; and that all lagoons installed in loamy sand or sandy loam soils on the Delmarva Peninsula should have a clay liner to protect groundwater quality.
Westerman et al. (1995)	Coastal Plain of North Carolina - Monitoring wells near two lagoons showed increased concentrations of NH_3-N and NO_3 and that there was continued leakage after the lagoons had been receiving waste for 3.5 to 5 years. Both lagoons showed seepage over a broad area but there was much variation in the concentrations of the waste in the monitoring wells. This indicated to the authors that there was more seepage from certain areas of the lagoon and the difficulty in accurately determining transport of leaked waste.

V. REGULATORY FRAMEWORK

The primary authority for managing animal waste lies at the state level, although local governments also have authority granted to them which allows limited regulation of animal production facilities. At the state level and in a few counties, granted authorities have been used to a limited degree in adopting closure provisions for unused animal waste lagoons. These regulatory references and the framework in which they operate are identified in this section.

State Regulations

The two state agencies with primary authority for managing animal waste are the Division of Water Quality (DWQ) and the Division of Soil and Water Conservation (DSWC). Both are within the North Carolina Department of Environment and Natural Resources (NCDENR). The division of responsibilities for regulating animal waste systems is such that the DWQ is responsible for permitting, inspection, and enforcement, while the DSWC provides technical and often financial support. Financial support is given through the cost share program that this agency administers for implementing agricultural management practices to protect soil and water resources, some of which are for animal waste. Both of the agencies mentioned here defer to another agency, the United States Department of Agriculture's Natural Resources Conservation Service[12] (NRCS), for many of the practice standards incorporated in the regulations for animal waste (e.g. lagoon design, land application of waste).

State regulations for animal waste are found in the section of the North Carolina Administrative Code entitled "Waste Not Discharged to Surface Waters". These regulations are promulgated by the Environmental Management Commission (EMC)[13]

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12 Previously named the Soil Conservation Service.

13 The EMC is a quasi-legislative body which has the authority for developing environmental regulations.

and are often referred to as the non-discharge or .0200 Rules (Heath 1996). Lagoons are managed under these rules because they are designed so as not to discharge to surface waters - except in the case of a storm that is equal to or larger than a twenty-five year, twenty-four hour storm (a storm of 24 hour duration that produces a total precipitation that has a probability of occurring only once every 25 years) (NCGS 143-215.10C(b)). No effluent standards or limitations for animal operations have been adopted by the EMC, as this is specifically prohibited by North Carolina (except as required by federal law or regulations (NCGS 143-215(e)).

In 1997, the NCGA adopted legislation banning components of new waste management systems at operations permitted by the state from the 100-year floodplain (NCGS 106-8039(a)(5)(a2)). However, the land application site used by a facility is not subject to this restriction. Other restrictions on location of lagoons include the following minimum setbacks: 100 feet from perennial streams (adopted in 1992) (15 NCAC 2H .0217(a)(1)(H)(vi)); 1,500 feet from an occupied residence not owned by the operation; and 2,500 feet from any school, hospital, or church (both adopted in 1995) (NCGS 106-803(a)(1-2)). A 2,500 foot setback was also adopted in 1997 from the following: outdoor recreational facilities; national parks; State Parks; historic property acquired by the state or listed on the North Carolina Register of Historic Places; and child care centers (NCGS 106-803(a)(2)). A minimum setback for lagoons from a neighboring property boundary was also established at 100 feet in 1992 but was extended to 500 feet in 1996 (NCGS 106-803 (a)(3)). In 1997, the NCGA also adopted a minimum setback of 500 feet from any well that supplies water to a public water system or that is used for human consumption (NCGS 106-803(a)(4-5)). An exemption from this setback was provided to wells located on the same parcel of land on which the lagoon is located and which only supplies water for use on that land or adjacent land, if it is under the same ownership (NCGS 106-803(a)(4-5)).

Under the .0200 Rules, swine operations with less than 250 animals[14] are deemed permitted as long as they remain in compliance with the regulations. Facilities with 250 or more swine must obtain permits, which can be accomplished in two ways. Operations may receive a Certificate of Coverage under a General Permit, which includes developing an approved animal waste management plan (WMP) or they may obtain a more stringent individual nondischarge permit. These latter permits are issued if it is deemed necessary by the Director of the DWQ. However, as of October 8, 1997, only 8 individual nondischarge permits have been issued (Michael Lewandowski Personal Communication October 8, 1997). Of these, six were issued to operations with innovative waste treatment systems (five of which utilize lagoons), and two were issued because of prior compliance problems at the facility.[15]

A WMP must contain several items, most of which are directed at curtailing environmental impacts or nuisance concerns associated with animal waste. These plans must be approved by a technical specialist[16] and consist of the items listed below.

1. A waste utilization plan (WUP) which includes the methods and areas to be used in land applying waste, and the soil and waste sampling methods for analyzing nutrient contents so that the wastes can be applied at agronomic rates.
2. An emergency action plan to follow in case of a spill so that corrective actions can be identified beforehand to expedite the response and minimize the impact.
3. Methods for disposal of mortalities.
4. Location of riparian buffers or their equivalent to minimize impacts to surface

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14 Threshold number for other animal operations are 100 cattle, 75 horses, 1,000 sheep, and 30,000 birds.

15 One of the permits was issued to Oceanview Farms because of a 25 million gallon lagoon waste spill and the other was issued because of inadequate land for application of waste (Mike Lewandowski Personal Communication October 8, 1977).

16 Technical specialists are designated by the Soil and Water Conservation Commission and in general include individuals with knowledge of animal waste management practices as determined by the USDA, NRCS, NCDA, or NCCES.

waters.

5. Checklist of potential odor and insect sources and methods of control so that the owner is aware of the best methods available for addressing the problems.

Operations constructed prior to December 31, 1993 are defined as Existing Systems and must have their WMPs certified by December 31, 1997. Those constructed after December 31, 1993 (New or Expanding Systems) must have a certified WMP before stocking animals and their waste treatment units must meet specific design and construction standards as provided by the NRCS and the DSWC. Should the DWQ determine that a facility does not have an approved WMP by the December 31, 1997 deadline, the facility may be required to obtain an individual nondischarge permit.

Two annual inspections are required to be completed to help ensure that permitted operations are in compliance with regulations. One inspection is conducted by a technical specialist and consists of an operational review (NCGS 143-215.10D(b)). This inspection focuses on the technical aspects of waste management and consists of a visual survey of the facility and a review of records related to the WUP such as waste application records, maps of irrigated fields, waste sample analysis for determining land application rates, daily rain on farm, and weekly lagoon levels. The other inspection is performed by the DWQ to determine if the waste management system is in compliance with terms of the permit and to determine if water quality standards are being violated (NCGS 143-215.10F). This inspection is accomplished through visual inspections, records reviews, and sampling from wastewater, groundwater, or surface water as needed (NCDENR Swine Waste Operation General Permit). A nominal permit fee is charged depending on the size of the facility and ranges from $50 to $200 (NCGS 143-215.10G).

Beginning on November 1, 1997, pilot inspection programs began in two counties. These programs are in Jones and Columbus Counties and will extend to October 31, 1998 (S.L. 1997-443 Section 15.4(a) (S352)). In these two counties, the DSWC will perform both an operations inspection and a permit compliance inspection (including a determination of whether water quality standards are being violated) (S.L. 1997-443 Section 15.4(a) (S352)). This latter inspection does not replace the annual

permit compliance inspection required by the DWQ. As part of these programs, the DENR is also required to "establish procedures within the local SWCDs to respond to complaints and reported problems previously referred only to the DWQ" (S.L. 1997-443 Section 15.4(a)). The purpose of the programs appears to be aimed at determining if the compliance inspections currently required by the DWQ can be effectively performed by the DSWC. To this end, the DWQ and the DSWC are to jointly prepare and submit reports, detailing the program's effectiveness, to both the Environmental Review Commission and the Fiscal Research Division (S.L. 1997-443 Section 15.4(b)). An interim report is due on April 15, 1997 and a final report is to be submitted on December 1, 1998 (S.L. 1997-443 Section 15.4(b)).

The 1997 NCGA also directed the EMC to develop a point system for violations of permits issued for animal waste management systems (NCGS 143-215.6E(a)). The new legislation outlines how points are to be issued, requiring that violations which result in the greatest harm to the environment and public health receive the most points and be considered significant violations (NCGS 143-215.6E(a)(1)). Violations committed willfully or intentionally are also to be considered significant (NCGS 143-215.6E(a)(2). The accumulation of three significant violations or the commission of one willful violation that results in serious harm, are to result in mandatory revocation of a permit (NCGS 143-215.6E(a)(4-5)). As part of the violation points system, the EMC is to develop methods for assigning points to violations and determining what total number of points will result in revocation of a permit (NCGS 143-215.6E(b). As of December 10, 1997, no regulations for implementing this mandate were actively being considered (Dennis Ramsey Personal Communication December 10, 1997).

The 1997 NCGA has also ordered the DENR to refer to the State Bureau of Examination any permit violations which may warrant a felony charge (NCGS 143-215.6B(k)). The DENR has also been charged with submitting quarterly reports to the Environmental Review Commission and the Fiscal Research Division summarizing activities related to implementing animal waste regulations, including: number of animal waste permits issued; number of inspections and reinspections performed by the DWQ

and the DSWC; number of violations found in the inspections; time required to perform the inspections; and status of enforcement actions taken for violations, including penalties that were imposed and whether they were collected or are in the process of being negotiated (S.L. 1997-443 Section 15.2 (S352)).

State Closure Provision

The one state regulatory provision for closing unused swine waste lagoons exists as a General Condition of the Swine Waste Operation General Permit (this condition is the same in the individual nondischarge permits). This condition states that "If animal production at the facility is to be suspended or terminated, the owner is responsible for developing, implementing and completing a 'closure plan' which will eliminate the possibility of an illegal discharge, pollution, erosion, and the potential for injury and shall be in accordance with NRCS lagoon closure standards in effect when the closure plan is developed and implemented" (NCDENR Swine Waste Operation General Permit).

The effect of this permit condition has not been interpreted as a mandate by the state for closing lagoons if they are no longer utilized. Rather, as explained by an Interagency Group,[17] if a lagoon is no longer used, an owner actually has two options for managing it. The unit may either be closed according to the NRCS's Interim Standards, as explained below, or it may continue to be managed as an operating treatment unit, with requisite WMPs and annual inspections.

The NRCS has developed an Interim Standard for closing lagoons in North Carolina. The Interim Standard designation distinguishes that this is a standard developed for use at the state rather than the national level (Harry Gibson Personal Communication June 17, 1997). Adopted approximately two years ago, the standard has undergone only modest changes and will remain valid for a three year period, at which

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This Group was created during the Regular Session of the 1996 North Carolina General Assembly to provide uniform interpretation of the .0200 Rules, this body has representatives from the DWQ, the DSWC, the NCDA, and the NCCES.

time it will be reevaluated for adoption. The standard is quite simple. It requires that all inflow devices and waste materials are to be removed from the impoundment and "reasonable efforts are to be made to remove all waste materials prior to closure" (NRCS 1997). Sludge is to be removed from the impoundment with earth moving equipment if the structure will support the equipment. Otherwise, waste is to be agitated and pumped out. In the latter case, the "depth of agitated waste material remaining in the lagoon may not exceed a maximum depth of more than one foot" (NRCS 1997). All wastewater and sludge removed from a unit is to be analyzed and applied to crops at agronomic rates, based on realistic yield expectations (R.Y.E.) for nitrogen. Cleaned structures may be filled with fresh water if the impoundment meets other NRCS standards. Otherwise some other material must be used to fill in the voided impoundment.

New and Expanding facilities and all other facilities registered with the state, whether they are still raising animals or not, must comply with permit conditions. This means that registered facilities must submit either a certified WMP or a closure plan by December 31, 1997 if they wish to remain deemed permitted. If they do not submit a WMP and do not close out the lagoon, the facility will be subject to an enforcement action from the DWQ for operating without a permit (NCDEHNR 1997c). This penalty may be as high as $10,000 per violation (each day operating without a permit may constitute a separate violation) (NCGS 143-215.6A). Owners of abandoned lagoons which are causing a water quality problem are supposed to be issued a letter requiring the operation to be properly closed to prevent further pollution (NCDEHNR 1997c). This applies to all inactive lagoons causing a water quality problem regardless of size. Other inactive lagoons will not be required to close. If a facility serving less than 250 swine ceases to operate, neither a WMP nor a closure plan is required. However, these facilities will be subject to the penalties identified above if they cause water quality violations (NCDEHNR 1997c).

Available records indicate that of the roughly 2,500 swine facilities that registered with the DWQ in 1993, 1,923 are still registered while approximately 577 have been removed from the registry (Sue Homewood Personal Communication August 12, 1997).

Removal from the registry could have resulted under three conditions: the operation was going out of business; the operation had decreased its population below the 250 threshold number required for permitting prior to January 1, 1997; or the operation had always been below the threshold requirements. According to the DWQ, roughly 450 swine operations had requested removal because they had decreased their populations below the 250 threshold number and approximately half of these operations are now completely out of business (Sue Homewood Personal Communication April 30, 1997). This means that there are potentially in excess of 225 lagoons that have the capacity to hold the volume of waste produced from a facility rearing at a minimum 250 swine, but are not required to have either a WMP or close their treatment unit.

County Rules and Ordinances

At the local level, eight counties in the state have adopted rules directed at intensive livestock operations (ILOs). These counties are Chatham, Columbus, Halifax, Nash, Scotland, Duplin, Richmond, and Robeson. In all counties, initial adoption of these rules was a result of the county health board exercising the power delegated to it by the state to adopt rules that are necessary to "protect and promote public health" (NCGS 130-39(a)). In Halifax County, the rules were originally adopted by the county health board in 1992 and were later adopted as an ordinance by the county commissioners in 1997 (Jeff Dillard Personal Communication January 16, 1998). In each county, the county health department implements the rules. For ease of explanation, throughout this section the Halifax ILO ordinance will be referred to as a rule.

In December of 1996, hog populations in these counties were highest in Duplin County (see Table 5). For that month, Duplin County ranked 1st in the state for total hog populations with a total of 2,100,000 hogs (NCDA 1997). The next highest populations for the same month were in Robeson County and Columbus County, which ranked 5th and 10th highest in the state respectively (with populations of 355,000 and 215,000 hogs, respectively) (NCDA 1997). The state rankings for Nash and Halifax were 20th and 23rd,

while Richmond and Chatham ranked 33rd and 42nd (NCDA 1997).

With the exceptions of Duplin, Robeson, and Richmond Counties', the ILO rules include requirements for closing inactive animal waste lagoons. Closure provisions include procedural and financial requirements (summarized in Table 6). Procedural requirements stipulate that a closure plan be submitted to the county health department if a facility ceases to operate. The purpose of this provision is to assure that ILO lagoons are closed in an environmentally protective and timely manner. To accomplish this, rules require owners of regulated ILOs to submit a closure plan for their waste treatment system at least 60 days prior to the final day of operation (in Chatham and Columbus Counties owners have 90 days after production ceases to submit a plan). Closure plans must comply with NRCS standards and be approved by a Technical Specialist. The rules of Halifax, Nash, and Scotland Counties specifically state that lagoons should be filled and revegetated after they are cleaned, however Halifax and Nash County also provide consideration for use of cleaned lagoons/ponds for wildlife purposes if the reclaimed area meets all state and Federal requirements for sludge removal. Columbus County's rule does not specify conditions for closure other than adherence to NRCS guidelines, thereby leaving the owner/operator with the option of either filling the cleaned lagoon with inert materials such as dirt or maintaining it as freshwater pond (if it is structurally capable of this under NRCS guidelines).

Four different time limits are used in the rules for closing inactive lagoons. ILO rules in Halifax County and Columbus County directly address the time limit for closing by requiring the submitted closure plan to be completed within three and two years, respectively, after the NRCS closure plan is approved. Similarly, Chatham County's rules specifically state that closure is to be completed within 12 months after submission of the closure plan, translating into a closure deadline of 15 months after the last day of operation. Scotland and Nash do not directly specify a time limit in which closure must be completed but may have indirectly established a maximum time limit of two years by stating that closure may be postponed for up to 24 months if the property is posted for sale.

Financial provisions are also included in the rules of Nash, Chatham, Scotland, and Halifax Counties. These clauses are designed to guarantee proper closure of an ILO lagoon by assuring funds will be available to clean the lagoon and that they will be provided by the owner of the ILO. Owners of an ILO facility must complete an agreement with the county that assures these funds through either a surety bond, cash or an equivalent security, or a certified guaranty. In all counties except Chatham, funds are to be assured at the rate of $2000 per acre foot of lagoon capacity. In Chatham, assurances are to be at the rate of $2500 per acre foot of lagoon capacity. Nash, Scotland, and Halifax County also provide that if lagoon closure is not completed in accordance with the rules, the health department director will notify the responsible party and within 30 days of receiving this notice, the responsible party is to give sufficient funds to complete closure. If a dispute arises over the closure, funds are to be deposited in an escrow account until the dispute is resolved. While Columbus County's rules do not require a financial assurity, they do contain a stipulation for the health department to recover expenses, other than administrative costs, for closing a lagoon, if an ILO owner does not voluntarily comply with the closure provision. Their rules state that these expenses will be considered a lien against all real estate owned by the owner/operator to the extent allowed under applicable laws, for one hundred eighty days prior to the time the facility ceased to operate.

Swine operations subject to the local closing requirements vary in each county. The two major factors that determine which facilities in the county will be affected are the ILO definition adopted by the rules and the exemptions allowed. In Nash, Scotland, and Columbus County rules, ILOs are those which meet the state threshold number for permitting under the .0200 Rules (250 hogs for swine operations). Neither Scotland County nor Columbus County exempt existing operations from any of the closure requirements. Therefore the twenty existing swine operations in Scotland County are subject to procedural and financial requirements (Teddy Locklear Personal Communication August 11, 1997). As of December 15, 1997, nineteen of the operations had met the financial requirements of the ILO rules (Teddy Locklear Personal

Communication December 15, 1997). Annual audits, indicating the presence of available funds for closure, were provided by eighteen of the swine operations - all of which are corporately owned facilities (Teddy Locklear Personal Communication December 15, 1997). The other two operations subject to the financial requirements are independently owned. One of these operations has met the financial requirement by providing a cash security (funds for closure have been placed in a secured bank account). The other independent operation has not yet provided a financial guarantee.

Health department closure requirements apply to eighty existing swine operations in Columbus County, all of which existed at the time their rules were passed (none have been permitted since adoption of the rules) (Marion Duncan Personal Communication December 9, 1997). Additional lagoons may also be subject to the closure provision as the Columbus County ILO rules contain a clause which is aimed at closing some lagoons in the county that served operations that are no longer in businesses. Although interpretation of this provision was still under consideration by county officials (director and staff of the Columbus County Health Department and the county attorney) on December 13, 1997, the Health Director has initially interpreted this article as requiring closure of lagoons which served ILOs that ceased operation within the five years before adoption of the rules (Marion Duncan Personal Communication December 9, 1997). Operations would have had to meet the health board's ILO definition at the time they ceased production to be subject to the provision. As of December 13, 1997, the Health Department had not initiated enforcement of this provision nor had the number of lagoons (or operations) subject to this provision been determined (Neal Floyd Personal Communication December 13, 1997). However, according to the health department's staff, as of November 1997, approximately eighteen swine operations have decreased their populations below the 250 threshold number of hogs that would qualify them as an ILO, and have requested to be removed from the state's register (Neal Floyd Personal Communication December 13, 1997). These operations may therefore be subject to closure under the rules.

In Nash County, the only operations which are required to meet closing provisions

are those that are new or that expand production by 10% or more. Since the Nash County Health Department has only issued one permit for a new facility since adoption of its rules and none have expanded, there is only one swine operation affected by either the financial requirements or the procedural requirements of the rules (Jay Smith Personal Communication August 8, 1997). A letter of credit was presented to meet the financial provision.

For the other two counties (Halifax and Chatham), ILOs are defined in a different manner. Halifax County uses the NRCS's Job Classification System to designate an ILO - which groups operations according to the volume of animal waste produced. The minimum sized swine operation regulated under these rules is one that rears 740 hogs. However, as all facilities in operation in Halifax County prior to January 27, 1997 are exempt from the rules' closure requirements and there have been no new swine facilities permitted in the county, none of the existing operations are subject to the financial or procedural closure requirements (Jeff Dillard Personal Communication August 11, 1997). In Chatham County, swine operations must raise at least 3,000 hogs to be considered an ILO. As of August 11, 1997 Chatham County had one existing and two proposed swine operations that meet this size criterion (Wayne Sherman Personal Communication August 11, 1997). This ordinance also has a provision that requires owners of abandoned ILO lagoons that were in existence as of the effective date of the rules (March 25, 1997) to submit and execute a closure plan within 12 months. How this clause will be interpreted has yet to be seen as the rules do not define an abandoned lagoon, a criticism of the rules according the county's health director (Wayne Sherman Personal Communication August 11, 1997). It is assumed that the provision is to apply to lagoons that served operations which met the rules' ILO definition. If this assumption is correct, there are no facilities that would meet this criterion. Unlike the rules in other counties, Chatham's rule states that the financial requirements are designed not only to guarantee proper lagoon and facility closure, but to ensure proper clean up of spills and remediation or abatement of violations.

Numerous changes to the Chatham rules have been proposed and will be

considered by the health board and the county commission in April of 1998 (Steve Seilkop Personal Communication March 4, 1998). Proposed changes to the closure provisions would limit the types of guarantees allowed for meeting the financial requirements to either a cash or equivalent security or a promissary note and deed of trust (the option of bonding has been removed). The proposed amendments also eliminate the requirement that closure plans be submitted for existing abandoned ILO lagoons. But, as it was likely there were no lagoons covered by this provision, this change has little to no impact.

Table 5

Hog Populations, State Rank, and Hog Operations (with > 250 hogs) in North Carolina Counties With Intensive Livestock Operation Rules

COUNTY	HOG POPULATION 12/1/96	STATE RANK 1996	NUMBER OF SWINE OPERATIONS WITH > 250 HOGS 3/26/97
Chatham	10,900	42	5
Columbus	215,000	10	80
Duplin	2,100,000	1	643
Halifax	85,000	23	24
Nash	89,000	20	34
Richmond	40,000	33	13
Robeson	355,000	5	65
Scotland	120,000	15	20

Source: NCDA 1997, NCDEHNR 1997a.

Table 6

Selected Provisions of Intensive Livestock Operation Rules/Ordinance Adopted in North Carolina Counties

	CHATHAM (Rules)	**COLUMBUS** (Rules)	**HALIFAX** (Ordinance)	**NASH** (Rules)	**SCOTLAND** (Rules)
ADOPTION DATE	3/97	12/97	4/92	6/96	11/92
ILO[1] DEFINITION	Classes[2]	State Threshold Numbers[3]	Classes[4]	State Threshold Numbers[5]	State Threshold Numbers[5]
CLOSURE EXEMPTIONS	None	None	ILOs Existing Before 1/27/97, If Not Expanding	Existing ILOs That Do Not Expand By More Than 10%	None
TIME LIMIT FOR CLOSING[6]	15 Months	24 Months	36 Months	24 Months	24 Months
FINANCIAL ASSURITY REQUIREMENTS	$2,500 Per Acre Foot Lagoon Capacity	None	$2,000 Per Acre Foot Lagoon Capacity	$2,000 Per Acre Foot Lagoon Capacity	$2,000 Per Acre Foot Lagoon Capacity

[1] ILO = Intensive Livestock Operation.

[2] Categories used in the Chatham County ordinance to classify animal production operations. The minimum sized swine operation regulated under this ordinance is one with a minimum of 3000 hogs.

[3] Columbus County uses the same threshold numbers as Halifax and Nash County (see footnote number five) but also further divides the operations into small, moderate, and large operations for applying setback standards. For swine operations the categories have the following number of live animals, small operations (250 to 4800), moderate operations(4801 to 9600), and large operations (more than 9600).

[4] Categories used in the Halifax County ILO Ordinance to classify animal production operations. These are the same as those of the NRCS's Job Classification System which groups operations according to the volume of animal waste produced. The minimum sized swine operation regulated under this ordinance is one which rears 740 hogs.

[5] Minimal numbers used to regulate animal operations, for swine operations this number is 250.

[6] Time allowed to close a lagoon after the facility submits an approved NRCS closure plan.

Source: Review of Intensive Livestock Operation Rules of Chatham, Columbus, Halifax, Nash, and Scotland Counties.

Robeson, Richmond, and Duplin Counties' ILO rules are distinct from the ones discussed above. These rules establish a process allowing ILOs to be investigated by the county health director to determine whether proposed or existing ILOs present a public health nuisance that should be abated. Although no specific requirements exist in the rules for closing animal waste lagoons, there remains the possibility that it could be used on a case by case basis. As of October 10, 1997, no actions had been taken in Robeson County to close out a lagoon using the rules (Kay Speer Personal Communication October 10, 1997). Related information for the other counties was not obtained. Under Robeson's and Duplin's rules, animal operations must have 100 animal units to be considered an ILO and therefore be subject to the rule. For swine operations, this translates into 250 swine weighing 55 pounds or more and 200 swine weighing less than 55 pounds. In Richmond County, swine operations must have 250 or more swine to be considered an ILO and therefore be subject to the ILO rules. Adoption dates for these counties are as follows: Robeson - September 28, 1995, Richmond - August 20, 1996, and Duplin February 8, 1998.

In addition to Scotland County's rules that have closure provisions discussed above, the health board also adopted rules identical to those of Robeson County - with the exception that the affected ILOs are those that meet the threshold numbers of the .0200 Rules.

Several other county health boards have considered adopting a ILO rules but for various reasons have not. First, the threat or fear of lawsuits has been a deterrent for at least two health boards. After the health director of the Bladen County Health Department received a letter from Carroll's Foods threatening to bring suit against the board of health if it adopted ILO rules (review of letter from Carrolls' Foods to Don Yousey, Bladend County Health Director, dated September 17, 1996), the board voted on October 8, 1996 to reject the proposed rules. In another instance, an Appellate Court ruling dissuaded Edgecombe County's Health Board from adopting ILO rules that it had already written and revised eight times (Jim Baluss Personal Communication June 6, 1997). In *City of Roanoke Rapids versus Peedin (*(NC Court of Appeals 1996)(478 S.E.

2d 528)) the court found that a rule which is adopted to protect public health could not make distinctions in regulating businesses based on "factors other than health." This, the court said, was a function of an elected body. The fear of the Edgecombe Board of Health was that the ILO rules it was considering would be prone to a lawsuit because it distinguished between new and old facilities (Jim Baluss Personal Communication June 12,1997).

Two other counties suggest different reasons for not adopting ILO rules. The Northampton County Board of Health, after examining the feasibility of adopting ILO rules over a five-month period in 1996, decided to wait for guidance from the state before formulating their own policies (Patricia Wood Personal Communication August 7, 1997). Specific reasons for this postponement were not given. To allow time for further research and consideration of adopting county ILO rules, the Northampton Board of County Commissioners adopted a one-year moratorium new intensive livestock operations (discussed on the following page). Finally, the Nash County Health Department identified the difficulties of obtaining the technical and financial resources needed to implement an ILO rule, as it has not historically been a function of the unit of government.

Legal actions have been taken against two boards of health which challenged the authority of the boards to regulate animal operations through their ILO rules. However, as the case against the Robeson County Board of Health and its Director is being settled out of court (William Smith Personal Communication October 17, 1997) and the other case in Chatham County is yet to be litigated, a legal precedent has not been established for the issues raised in these actions. In the case between Carroll's Foods and the Robeson County Board of Health and the Health Director, the question raised is the legal authority of a board of health to project or abate a public health nuisance (William Smith Personal Communication October 17, 1997). In the May 8, 1997 charges filed against Chatham County's Board of Health (by the Chatham Agribusiness Council), the authority of the board to regulate the industry is questioned in light of the ruling in *City of Roanoke Rapids versus Peedin* (Bob Gunn Personal Communication October 13, 1997).

One possible avenue for securing ILO regulations at the county level is for county commissioners to exercise their police power in these matters. County commissioners have been delegated a broader power to adopt regulations than that which has been given to health boards. Rather than being restricted to adopting rules based on a finding that they are necessary to protect public health, as is the case with health boards, commissioners have the power to define and regulate conditions which are "detrimental to the health, safety, or welfare of its citizens and the peace and dignity of the county " (NCGS 153A-121(a)).

As of December 13, 1997, the only ILO ordinance containing lagoon closure provisions that had been adopted by a county commission was the one in Halifax County. However, in 1997 four county commissions adopted ordinances containing moratoria on new animal operations in their counties. These counties included Craven, Edgecombe, Northampton and Beaufort. These moratoria extend for one year (see Table 7 for adoption and moratorium dates) and prohibit the construction of new animal operations that would require permitting under the state's .0200 Rules.

In a recent federal court decision, the Craven County ordinance was sustain against federal constitutional challenge (*Craven County Livestock Association versus Phillips*, July 29, 1997, 4:97-CV-57-H1). Plaintiffs in the civil action against the Craven County Board of Commissioners alleged that the county ordinance violated their rights under the United States and North Carolina Constitutions (*Craven County Livestock Association versus Phillips* July 29, 1997 4:97-CV-57-H1). The court denied motion for judgement and dismissed the case on the basis that no violations of the plaintiffs' rights could be found under federal statutory or Constitutional law (*Craven County Livestock Association versus Phillips* July 29, 1997 4:97-CV-57-H1). Claims by the plaintiffs that the ordinance was unconstitutional under state law were also dismissed because the court found that these matters should be decided in North Carolina courts rather than in federal courts. The plaintiffs are continuing to pursue their claims through an appeal of these decisions filed on August 27, 1997 to the United States Court of Appeals for the Fourth Circuit.

In addition to the moratoria, the ordinances adopted by the county commissioners also direct that the commissioners research and make recommendations on what, if any, actions should be taken for adopting county ILO regulations. Craven County and Beaufort County provided that study committees be formed to fulfill this provision. On December 16, 1997, the study committee in Craven County submitted its final report. One of the fifteen recommendations in the report suggested, based on a finding that "lagoon closure is a serious problem," that the county board of commissioners "should open discussions with the state legislators to address this issue in the North Carolina General Assembly" (CCBC 1997). Recommendations of the study committee in Beaufort County are not due until February 4, 1998 - three months before the moratoria expires. For the other two counties, Northampton and Edgecombe, recommendations on further actions are to be reported before the end of the moratoria.

Table 7

Adoption and Moratoria Dates for North Carolina Counties with Ordinances Containing Moratoria on New Animal Operations

(including December 1996 Hog Population and State Rank)

COUNTY	ADOPTION DATE	MORATORIA PERIOD	HOG POPULATION DEC. 1, 1996	STATE RANK DEC. 1, 1996
Beaufort	5/5/97	5/5/97 - 5/4/98	100,000	17
Craven	2/25/97	2/17/97 - 2/16/98	91,000	19
Edgecombe	5/5/97	5/5/97 - 5/5/98	105,000	16
Northampton	3/17/97	3/6/97 - 3/6/98	167,000	13

Sources: County Ordinances of Beaufort, Edgecombe, and Northampton, and Gwen Bryan Personal Communication December 11, 1997.

Zoning Authority

In August of 1997, the NCGA granted all counties in the state the authority to include swine operations in their zoning ordinances (NCGS 153A-340(b)(3)). Prior to this legislation, swine farms were included in a list of "bona fide" farms that were exempt from county zoning authority. The new authority allows counties to zone for, but not exclude, new swine operations that have a waste management system designed for 600,000 pounds of steady state live weight (NCGS 153A-340(b)(3)).

In developing zoning ordinances, counties must decide which swine operations they have authority to zone under the new legislation. In making this decision, the size of a waste management system that serves 600,000 pounds of swine has to be determined. An analysis prepared by the Moore County Agricultural Extension Service shows that based on nitrogen production, a waste management system designed for 600,000 pounds of swine can serve a wide range of operation sizes depending on the type of swine facility under consideration. The number of animals that would generate the amount of nitrogen produced from 600,000 pounds of swine at a farrow-to-finish operation would be 423 sow units (where one sow unit is equal to the sow and all offspring fed to a market weight of 240 pounds) (information supplied by the Moore County Extension Service to Milton Heath). For a farrow-to-feeder operation, it would equate to 1149 sow units (where one sow unit is equal to a sow and all offspring grown to a weight of 50 pounds). For a farrow-to-weanling operation, it equates to 1,385 sow units (where one sow unit is equal to a sow and all offspring raised to weaning weight of 10-15 pounds). Finally, at operations where every hog is counted individually, feeder-to-finish or weanling-to-finish operations, it equates to 4,444 or 20,000 hogs, respectively. In light of these calculations, it is clear that developing county zoning ordinances for swine operations under the new authority will not be as straightforward as it initially appears.

VI. LAGOON CLOSURES

Fewer than thirty swine lagoons have been recorded as closing since 1994. The DWQ has required registered animal facilities to submit a record of lagoon closure since May of 1996. As of August 12, 1997, fewer than 20 lagoon closure report forms have been submitted to the agency (Sue Homewood Personal Communication August 12, 1997). Other records, held by the DSWC, document another eight completed lagoon closures and an additional 27 which are pending, using funds from the North Carolina Agriculture Cost Share Program for Nonpoint Source Pollution (NCACSP). A summary of these closures is presented in this section.

Although there are federal agencies which provide technical assistance for closing animal waste lagoons, there were no federal agencies identified which provide financial support on a regular basis or which have records of having funded closures. The one federal agency which has historically provided funding for agricultural Best Management Practices (BMPs), the Farm Service Agency (FSA) (formerly the Agriculture Conservation and Stabilization Service), has never cost shared for closing lagoons (Timothy Jones Personal Communication June 17, 1997). The NRCS, which now jointly administers the Environmental Quality Incentive Program (EQIP) with the FSA, may have funded some swine lagoon closures in the state during its last fiscal year but was not able to provide any information on how many were closed or how much funding was provided (Tessa Chadwick Personal Communication October 17, 1997)

North Carolina Agriculture Cost Share Program Closures

As of June 1, 1996, the practice of closing animal waste lagoons was added to the list of BMPs eligible for state cost share funds under the NCACSP (NCGS. 143-215.74(b)(5)). The Soil and Water Conservation Commission (SWCC), which develops and adopts the rules implemented by the DSWC, has established that financial assistance may be provided to close out lagoons or waste storage ponds when farmers are going out of business or when a landowner, who was not previously the operator, has an

abandoned waste storage or treatment unit on his/her property (NCDEHNR 1996).

The SWCC has also developed a set of guidelines for offering financial assistance for this BMP. First, the operator or landowner could not have received cost share funds from the NCACSP to install the waste system.[18] Second, the lagoon must either be creating a water quality problem or present a potential water quality problem if it is not closed. The Soil and Water Conservation District in which the lagoon lies is supposed to "clearly demonstrate" these latter conditions when seeking approval of a closure contract. The way the NCASCP is set up, each district decides its priorities for soil and water protection and seeks money from the NCACSP accordingly. Systems which will no longer be used because a new lagoon will be constructed to meet the .0200 Rules are also eligible for cost-share closure funds. Third, landowners must also agree that they will not re-implement the cleaned lagoon or storage pond and that a new confined animal operation will not be started on the property for five years thereafter. Cost-share funds are limited to pay for removal of waste and stabilization of the site. They are not to be used for purchasing fill material. As with other cost-shared BMPs, the program pays 75% of the actual cost and the contractee pays 25%. The maximum cost-share funding allowed for this BMP is $15,000.

Two sources of funds have been used by the Program for closing lagoons. The primary source of funds for the closure contracts is the yearly budget as appropriated by the legislature from the General Fund. The Program's last budgeted amount was for $10.3 million in non-reverting, recurring funds (NCDEHNR 1996). The second source of funds was from the $500,000 special appropriation to the NCACSP by the 1995 General Assembly for capital expenses associated with animal waste management (NCDEHNR 1995). Priority for these funds was given to small family agricultural operations or small family farms (SFF). The Soil and Water Conservation Commission resolved that these

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18

Cost-share funds have been available for retrofitting operations that had no increase in production after February 1, 1993.

operations would be identified as operations that were family operated, had substantial labor provided by the family, and had total livestock operations below the following numbers: 135 milking cows; 75,000 layers; 40,000 broilers; 20,000 turkeys; 2,500 swine; 150 beef cattle (Resolution of the SWCC, November 13, 1995).

As of May 15, 1997, the DSWC's Program had initiated 35 cost share contracts for closing swine waste treatment systems consisting of 33 lagoons and 2 holding ponds. Specific information for individual closings is contained in Table 8 at the end of this section. Of the 35 contracts, four will use SFF funds, and the remaining 31, eight of which have been completed, will use funds from the Program's recurrent appropriations. Only four contracts have been initiated for closing lagoons which did not serve swine operations (three served dairy farms and one served a poultry operation).

The total cost shared funds expended for the completed swine lagoon closures was $53,694. This amount was actually $193 less than the estimated costs. Given this, if the estimated amounts for closing the remaining lagoons is assumed to remain accurate, the total cost shared amount for the uncompleted contracts will be approximately $241,119, bringing the total expenditures to $287,813. These funds were appropriated as follows:

YEAR	AMOUNT	NO. OF CONTRACTS	AVERAGE COST
1994	$2,403	1	$2,403
1995	$46,239	5	$9,079
1996	$171,326	18	$9,320
1997	$71,285	7	$6,479

Most of the lagoons in the contracts are smaller and older, although one in Duplin County was only 6 years old. This is to be expected because of funding criteria and the general health of the swine industry. Requests for closure funds have been dispersed throughout the state - the 35 individual contracts are represented by 24 counties. Six of

the closure contracts are for lagoons in Pitt County; Wake and Washington each have 3; Sampson and Johnston each have 2; and the remaining 19 counties each have 1. The low numbers in each county may represent the fact that districts do not consider lagoon closures to be a priority (as many of the districts are heavily involved with certifying animal waste plans) or that it is simply not currently considered a problem, especially in any one area. The higher number of closures in Pitt County may represent a greater awareness of the problem and availability of funding for closure from the NCACSP by the District personnel and lagoon owners. The reduction in number of contracts in 1997 may be reflective of the time and money dedicated to certifying the waste treatment systems of animal operations and retrofitting lagoons (District technicians provide assistance with many activities outside the scope of the NCACSP).

Closure costs varied considerably among the operations, ranging from $692 to $25,833 per closure and from $5 to $32 per 1,000 gallons of waste. Average cost per closure was approximately $9,000 in 1995 and 1996 but declined to $6,479 in 1997. The number of variables which contribute to costs and the wide range of characteristics at each lagoon prevents any cost trends from being evident. Factors affecting closure costs include amount of sludge and liquid waste in the lagoon; consistency of the sludge, which affects whether the sludge material could be agitated and subsequently pumped from the lagoon or whether excavation was needed; amount of land available for spraying and distance from lagoon; amount of disturbed area to be revegetated; and availability of labor.

Insufficient documentation on funding eligibility prevented completion of a summary of this information. Although a few contracts did contain a sentence or partial reference which identified that the operation met the SWCC's funding guideline of going out of business, it is unclear if any of the lagoons qualified because they had been abandoned. There is also not a definition of an abandoned lagoon in the SWCC's guidelines (nor in any of the animal waste regulations). Additionally, the degree of water quality problems associated with each lagoon was not "clearly demonstrated" in the contracts, with the exception of the two operations which had received citations from the

DWQ. One of the citations was a Notice of Violation (NOV) issued to a 40-year old operation in Bertie County for a minor discharge (Vic Thompson Personal Communication October 7, 1997). The other citation was a Management Deficiency Notice,[19] issued to an operation in Robeson County because of waste seepage into the surrounding soil (David Hedgepeth Personal Communication October 8, 1997).

Two final notes on the cost-share closure deserve mention. First, in one contract, a company did not submit a bid for the waste removal because the lagoon was in such a state that the company did not want to risk removing the waste. Details of the conditions or the risk were not included in the contract documents but the importance of the issue is that the costs may increase and the condition of the lagoon may deteriorate over time. Also, an experimental type of "biological cleaning" is being tried at two of the facilities (contracts in Camden and Pasquotank County) to facilitate decomposition of lagoon liquids while still in the lagoon. This technique was mentioned in the contract as being more cost-effective than land application. However, even if it does prove effective, it will require the removal of sludge to meet NRCS closure standards because the process does not decompose this material.

19

A Management Deficiency Notice is issued when a management procedure has not been followed (e.g. lagoon levels have not been maintained at specified levels).

Table 8

SUMMARY OF NORTH CAROLINA AGRICULTURAL COST SHARE PROGRAM'S SWINE WASTE LAGOON CLOSING CONTRACTS 1994-1997

COMPLETED CONTRACTS

COUNTY	CONTRACT YEAR	AGE	ESTIMATED COSTS	FUNDS EXPENDED	LAGOON CAPACITY	WASTE (GALLONS)	COST PER GAL.	YEARS ABANDONED
EDGECOMBE	1996	15	10,500	10,000	NA	1,750,000	6	NA
HYDE	1996	18	10,725	14,255	36 SOW	700,000	20	12
PERSON	1996	10	3,341	3,341	400 SWINE	370,800	9	NA
PITT	1996	20	14,160	14,160	3 ACRES	442,000	32	6
SAMPSON	1994	13	1,903	2,403	NA	250,180	8	NA
SAMPSON	1995	56	948	1,408	200 SWINE	230,000	4	NA
WASHINGTON	1995	19	8,088	10,965	200 SOW	1,500,000	5	NA
WAKE	1997	13	692	692	14 ACRES	90,000	8	3
TOTALS			$83,887	$93,694				

UNCOMPLETED CONTRACTS

COUNTY	CONTRACT YEAR	AGE	ESTIMATED COSTS	FUNDS EXPENDED	LAGOON CAPACITY	WASTE (GALLONS)	COST PER GAL.	YEARS ABANDONED
ALAMANCE	1996	10+	1,340		.6 ACRES	185,690	7	2+
CHATHaM	1996	21	3,865		.45 ACRES	640,000	6	1
CAMDEN	1997	25	10,174		.39 ACRES	1,186,405	9	3
CHOWAN	1997	20	11,094		.66 ACRES	2,626,288	4	2
GATES	1997	31	375		.02 ACRES	20,000	19	1
JOHNSTON	1995	20	1,373		.43 ACRES	199,370	7	NA
MARTIN	1996	20+	15,000		32 ACRES	1,300,000	12	2
MOORE	1996	19	1,221		.1 ACRES	120,000	10	3
NORTHAMPTON	1997	20+	10,000		NA	1,400,000	7	3
PASQUOTANK	1997	25	2,527		.34 ACRES	325,029	8	1
PITT	1995	10+	6,750		NA	NA	NA	NA
PITT	1997	20+	6,750		.34 ACRES	600,000	11	2
PITT	1997	20+	4,313		450 SWINE	475,300	9	NA
PITT	1997	20+	11,250		.42 ACRES	855,502	17	NA
PITT	1996	15+	19,648		1.2 ACRES	1,746,492	11	NA
ROBESON	1997	20	8,745		.54 ACRES	1,116,000	8	NA
ROWAN	1996	15	17,555		256,056 CU FT	1,922,799	9	6
STANLY	1996	30	3,372		228 ACRES	562,000	6	2
WAKE	1996	15	5,923		.8 ACRES	2,220,000	3	5
WAKE	1996	15	10,588		1.0 ACRES	2,240,000	5	3
WASHINGTON	1995	20	25,833		NA	750,000	34	NA
WASHINGTON	1996	17	15,382		.3 ACRES	560,000	27	10
WAYNE	1997	30	5,365		.35 ACRES	476,850	11	< 1 MONTH
TOTAL			$198,416					

CLOSURES FUNDED WITH 1996 SPECIAL APPROPRIATIONS FOR SMALL FAMILY FARMS

COUNTY	CONTRACT YEAR	AGE	ESTIMATED COSTS	FUNDS EXENDED	LAGOON CAPACITY	WASTE (GALLONS)	COST PER GAL.	YEARS ABANDONED
BERTIE	1996	40+	8,902		.33 ACRES	913,040	10	NA
DUPLIN	1996	6	15,000		NA	NA	NA	NA
JOHNSTON	1996	25+	2,051		NA	248,411	8	NA
LEE	1996	17	9,750		NA	960,000	10	NA
TOTAL			$35,703					

SOURCE: Closure contracts held by the North Carolina Division of Soil and Water Conservation, Raleigh NC, May 1997.

VII. RELATED CLOSURE REGULATIONS

Animal Waste Lagoon Closure Regulations in Other States

Little action has been taken in any of fourteen states contacted for legislative or regulatory initiatives related to closing unused animal waste lagoons. These fourteen states were contacted to identify possible policy options for North Carolina and were chosen on the following basis: the nation's largest swine producers and therefore the states more likely to have similar needs (Illinois, Indiana, Iowa, Nebraska, Minnesota, and Missouri); surrounding states which would be more likely to have similar geological and environmental considerations for regulatory purposes (Georgia, South Carolina, and Virginia); and states which were suspected to have related regulations because of information obtained during other research (Arkansas, Oklahoma, South Dakota, and Wisconsin). At the time of contact (June 1997) none of these states had adopted statutes or regulations specifying time limits for closing lagoons which are no longer being used. However, South Carolina did report it had been considering a regulatory requirement mandating that a facility close its waste treatment unit within 2 years after it ceases to operate (Marian Sodler Personal Communication June 9, 1997).

Three of the states contacted have adopted mechanisms for securing funding from animal operations for closing animal waste lagoons. Indemnity Funds were created by statute in both Iowa and Missouri and a bonding mechanism was established in Oklahoma. Provisions of the these statutes are discussed below.

Iowa

Iowa adopted its funding mechanism for closing abandoned lagoons in 1995. Referred to as the Indemnity Fund, it has a cap of one million dollars and is to be used exclusively for cleaning up ILOs that a county has taken possession of for non-payment of real estate taxes. Monies come from two sources, a one-time fee on permitted ILOs that is retroactive for the last 10 years and civil penalties imposed on ILOs. The one-time fees are assessed at the following rates:

Waste Treatment Unit Capacity By Animal Weight (lbs)	Poultry	Cattle and Other Species
<625,000	$0.02/lb	$0.05/lb
625,000 - 1,250,000	$0.03/lb	$0.08/lb
>1,250,000	$0.04/lb	$0.10/lb

It is estimated that a 14,000 head capacity swine finishing operation would pay a fee of approximately $560 (Iowa's 1995 Animal Feeding Operation Act H.F. 519).

Missouri

Missouri enacted its version of an Indemnity Fund in 1996. Only owners or operators of concentrated animal feeding operations with a capacity of greater than 7,000 animal units[20] and which uses water to flush animal waste into a treatment unit must pay into the fund. The payment rate is a flat fee of ten cents per animal unit. Payments begin on the first year anniversary of the permit issuance date and are due on the same date each year for the next nine years. Funds are invested by the state if not immediately needed, with all investment income reverting back to the Fund. A provision also exists which requires that all monies paid into the fund by an operation be returned if the business successfully closes its facility.

Funding is restricted for closing lagoons which meet the following conditions: pose a threat to human health or the environment; have a capacity of serving at least three

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[20] Animal units are based on the amount of waste produced at a facility. The total number of each type of animal produced at the facility is multiplied by a factor which estimates the contribution of waste from that species. These factors are: for slaughter or feeder cattle, 1; dairy cattle, 1.4; swine (>55 lbs.), 0.4; swine (< 55 lbs.), 0.1; and horse, 2.

hundred animal units; and is real property that has been abandoned[21] or that has been placed in the control of the state, a county, or a municipal government due to bankruptcy or failure to pay taxes. There is also a cap of $100,000 for each closure and expenditures are restricted to covering the minimum level of cleaning necessary to protect human health and the environment. As a means of cost savings on fill material, lagoons are to be maintained as ponds if they are capable of meeting the NRCS's Standard for Ponds (Standard #378).

Oklahoma

Oklahoma's financial assurity statute, passed in 1997, requires that every licensed animal operation using a liquid animal waste management system provide "evidence of financial ability to comply with the requirements for closure of retention structures and other waste facilities" (House Bill Number 15822, Section 15 A, Oklahoma General Assembly, 1997) If an operation does not have any outstanding fines or contempt citations it may post a Category A surety. This type of surety simply consists of a financial statement listing assets and liabilities that show a net worth based on the schedule below for different lagoon sizes. A release statement must also be included to allow verification of the listing.

Category A Surety	
Lagoon Capacity (aus)	Surety Amount
> 300 - 1,000	$10,000
1,000 - 2,000	$25,000
>2,000	$50,000

21

Abandoned property is considered to be real property which was previously used for or which has the potential to be used for agricultural purposes and which has been placed in the control of the state, a county, or a municipal government, or an agency thereof, through donation, purchase, tax delinquency, foreclosure, default or settlement. It must also have been vacant for at least three years.

Otherwise a Category B Surety is required in the amount of $25,000. Sureties may include an irrevocable commercial letter of credit, cash, cashier's check, Certificate of Deposit, Bank Joint Custody Receipt, other negotiable instrument or blanket surety bond. If the operation's liabilities in the state are less than $25,000, the state may lower the $25,000 surety normally required but not below what would be required to properly close the facility. If a facility operates under a Category B surety and has no outstanding fines at the end of three years, it then may post a Category A surety. Regardless of the type of surety the animal operation is under, additional amounts of a Category B surety may be required if it is shown that an operation is polluting. However, the total Category B surety cannot exceed $5.00 per animal unit at the facility.

Unlike the other states' financial assurity statutes, Oklahoma's statute does not restrict funds to use for cleaning up only abandoned property. Instead, the law contains a provision which allows the state to use secure funds equal to the amount of closing any surface impoundment or removing any equipment "if the department, after notice and an opportunity for hearing, determines that the animal feeding operation . . . has neglected, failed, or refused to close any surface impoundment, or remove or cause to be removed any equipment . . ." (House Bill Number 15822, Section 15 A, Oklahoma General Assembly, 1997).

Closure Policies for Other Storage/Treatment Units

Municipal sewage lagoons, industrial wastewater lagoons, underground storage tanks, and solid waste landfills are other treatment/storage units that pose some degree of risk to ground and surface water. Other units, such as hazardous waste landfills also pose similar risks but are not considered here. Municipal sewage lagoons and industrial

wastewater lagoons[22] referred to in this section are those that are regulated as nondischarging units. Although permits are issued by the DWQ for these systems, closure is not required (Randy Kepler Personal Communication October 15, 1997, Michael Allen Personal Communication December 16, 1997). The DWQ has also not adopted any specific standard procedures for closing out unused municipal lagoons (Randy Kepler Personal Communication October 15, 1997). However the agency requires that when wastes are removed, disposal must conform with requirements that are found in 40 CFR 503. These specifications are similar to the NRCS's Interim Standard for Closing Animal Waste - with the exception that sludge application must be limited in each area by maximum buildup concentrations (Randy Kepler Personal Communication October 15, 1997). Standard procedures for closing industrial lagoons have also not been developed but it is reported that the DWQ Regional offices use the NRCS Interim Standard for Closing Lagoons as a guideline for closing industrial lagoons (Michael Allen Personal Communication December 16, 1997). No specific government funding sources were identified for closing either of these types of treatment systems.

The third category of units that pose risks to water resources is underground storage tanks (USTs). USTs, as defined by North Carolina regulations, are used for storing petroleum products and other hazardous substances (note that hazardous wastes are regulated under a different set of provisions) (NCCES 1996). In general, USTs are either used as farm or residential tanks (generally containing substances that are not for resale, such as motor fuel or heating oil) or are used commercial purposes. Those used for commercial purposes are referred to as regulated underground storage tanks (RUSTs). RUSTs must be registered with the state and must comply with specific design and operating procedures (15A NCAC 2N) (NCCES 1996). Owners or operators of RUSTs

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22

As discussed here, industrial lagoons are units which are used to treat/store organic wastes such as those resulting from food or fiber production and at coal powered electric plants. Few of these lagoons exist in the state as most industries either treat their waste on site and then discharge into a water body or perform some type of pretreatment and then route wastes to a municipal treatment plant (Michael Allen Personal Communication December 16, 1997).

must maintain the tank system and protect the environment by providing the following: a leak detection system; corrosion protection; and spill and overfill prevention devices (15 NCAC 2N). Similar to the WMPs, records for RUSTs must be maintained to document compliance with regulations and are to include the following items: a diagram with the location of the RUST; total storage capacity of the tank; type of petroleum stored; and year the tank was installed. RUSTs in operation after December 22, 1988 are considered to be in use until they are closed (NCCES 1996). Closure policies for regulated underground storage tanks (RUSTs) are very similar to those for animal waste lagoons. Closing a system requires that the tank be emptied of contents, and then either removed or filled with a solid inert material (e.g., sand) (NCCES 1996). A Commercial and a Noncommercial UST Trust Fund were established by the 1988 NCGA to assist in paying for cleanup of petroleum contamination from USTs. To be eligible for funds, an owner must be in good standing with the state. This means that he/she must have complied with all regulations for USTs and must have paid annual registration fees. These fees range from $150 to $225. Funds cover the costs of cleanup, as well as personal injury and property damage to third parties resulting from contamination caused by leaks or discharges from the UST. There is a $100,000 deductible for commercial tanks that must be paid before third party damages are disbursed. Also, there is a $1,000,000 cap per occurrence on both funds. The state's Groundwater Section of the DWQ has adopted guidelines for soil and groundwater remediaton which are applicable for contamination around an UST.

The fourth category of units that may pose environmental risks to ground and surface water is solid waste landfills. State regulations have recognized the potential for liquids to leak from these units and are requiring all landfills that do not meet new design standards (which includes an impermeable liner requirement) to either meet the new standards or close before December 31, 1997 (Phil Prete Personal Communication December 19, 1997). It is approximated that half of the 60 solid waste landfills in the state do not have liners and that most of these will be closed (Phil Pret Personal Communication December 19, 1997). Regulations for closing these units include a

requirement that the landfill be capped to prevent water from entering the units and that groundwater monitoring be performed at the landfill site for a period of 30 years after the landfill is sealed in order to detect seepage of contents (Phil Prete Personal Communication December 19,1997). No funding sources are available from state government for closing these landfills. It is assumed that landfill owners, in anticipation of the closure and groundwater monitoring requirements, will have adjusted their tipping fees for disposal of materials at both old landfills and new landfills, to finance these activities (Phil Prete Personal Communication December 19,1997).

VIII. CURRENT WASTE TREATMENT RESEARCH

The importance of the swine industry to the agricultural economy in North Carolina and other states, coupled with the environmental concerns of using lagoons and spray irrigation for treating the industry's waste, has increased research of waste treatment technologies. Research is being conducted on methods which improve currently used practices and on new treatment technologies. Much of this research is being conducted through efforts based at North Carolina State University (NCSU) and is summarized below.

At the Animal and Poultry Waste-Management Center[23], eleven existing swine waste treatment technologies are being evaluated using funds from a $1 million appropriation from North Carolina's Governor, James B. Hunt (NCSU 1997). The funds are distributed under contract by DENR.

Five of the eleven projects are investigating the separation of swine waste into solids and liquids as it leaves the confinement area (NCSU 1997). The purpose of this separation is to yield a solid which can be transformed into a useable form and a liquid which has a low concentration of dissolved waste (nutrients). Four of the five projects which employ separation techniques, produce value-added products, including soil amendments and an ingredient for cattle feed[24]. One of the more innovative projects that produces a soil amendment involves placing the separated solids into a bed containing red worms, which can be harvested and sold (markets permitting). Waste from the red worms, referred to as castings, is the resulting soil amendment. Of the other six

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23

The Center was created in 1994 as a means of coordinating and advancing research on animal waste management and treatment technologies (NCSU 1997). The Center is a research partnership of the University, the private sector, government, and non-profit agencies. Research through the Center is supported by membership fees and appropriations by state and federal government (NCSU 1997).

24

The Center is also funding the research on a solids separation project that incorporates peanut shells into solid materials for the purpose of yielding a soil amendment. This project is not funded through the 1996 NCGA appropriation.

technologies being investigated through the Center, three use aeration to increase aerobic decomposition of waste located in a lagoon, one uses an anaerobic digester, and one uses a sequencing batch reactor that may yield a sludge which can be used as a soil amendment. In all of these projects, a waste lagoon is part of the treatment system.

Two additional treatment systems, which are commercially available but which are not widely used, are also being investigated through the University (NCSU 1997). The first is a system designed by Animal Waste Abatement System Holding Company (AWASH) and uses a scaled down version of a municipal waste treatment plant (NCSU 1997). A concrete basin is used to capture waste leaving the confinement area. In the basin, solids settle out and aeration is used to increase aerobic metabolism. Liquids are transferred to a lagoon, and although not stated in the project description, it is assumed that solids are land applied. This project is funded by the NCDA and is installed at Cherry Farm near Goldsboro. The second system under investigation was designed by AgStar - an U.S. Environmental Protection Agency Program. The system is located at the Barham Farm swine operation near Clayton. The system uses a plastic cover over a lagoon to collect methane for use in generating electricity. Excess liquid wastes are stored in a lagoon.

Through a research consortium[25] and other efforts based at NCSU, related swine waste management issues are also being studied. The list of research includes the following: economic analysis of alternative waste management technologies; a method to separate waste into solids and liquids; and methods of reducing lagoon odors, altering swine feed content to yield waste with both lower nutrient and metal concentrations, and reducing impacts of land application. Included in the research on improving land application methods are studies of using constructed wetlands for treating wastewater and using riparian buffers (grassed and forested) and wetlands to reduce runoff from land

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25

A research consortium was formed in 1996 by NCSU and Iowa State University to fund research related to waste treatment. Four other universities, Michigan State University, the University of Missouri, Oklahoma State University, and Purdue University, joined the consortium in the early part of 1997. As of July 1997, twenty-three projects had been awarded research grants (NCSU 1997).

applied waste. A project is also being funded for the purpose of organizing a symposium and developing a book on the state of the art of new waste treatment technologies (NCSU 1997).

In summary, most of the research for new waste treatment technologies is focused on separation of swine waste into solids and liquids as it leaves the confinement area. Regardless of the treatment method under investigation, the overwhelming majority employ a waste lagoon in the process to some degree. Additionally, the majority of the research mentioned in this section has either not been initiated or is still being evaluated. It is therefore still unknown which technologies will prove to be not only technologically and economically feasible but also environmentally acceptable.

IX. SUMMARY AND RECOMMENDATIONS

Until the last few years, little reason existed for investigating the issue of closing inactive lagoons. This need has now been presented because over the last decade, lagoons in the state have increased substantially in both size and number. During this time, environmental risks associated with swine waste lagoons have been recognized. Recognition of these risks has precipitated more stringent animal waste regulations and a directive by the 1997 North Carolina General Assembly to the NCDA to develop a plan for phasing out the use of anaerobic lagoons as a primary method of waste treatment for the swine industry (House Bill 515, Section 12.6, Part XII, , NCGA, June 19, 1997). The environmental risks associated with lagoons, particularly those from seepage and overflows, remain until the unit is closed. The degree of environmental and public health risks will vary with individual lagoons depending on the following: size of the impoundment; the amount, concentration, and type of waste (sludge and supernatant) in the impoundment; design standards and setback requirements at the time of construction; surrounding soil matrix and groundwater flow; location relative to groundwater, surface water, and other sources of pollution; and level of appropriate management. Possibilities also exist that lagoons pose risks to human health, particularly by contributing to nitrate contamination of drinking water. However, because the extent of this contribution is not known additional research in this area is needed before conclusions can be made with respect to these potential impacts on human health. Under the current regulatory scheme, there are no state regulations requiring lagoons of any size to close when they become inactive. Nor does any state agency have authority, under any conditions, to require lagoon closure.

State animal waste regulations require that active swine operations raising 250 or more hogs swine obtain an operating permit and maintain their anaerobic lagoons (and other components of the waste treatment systems) under a WMP. Should the facilities cease to operate, they have the option of either closing the lagoon or maintaining it under a WMP. There are approximately 3,000 permitted swine facilities in the state that have

this option - under state regulations. Roughly 3,000 other swine operations in the state are not regulated by the state because they fall below the 250 threshold number of the .0200 Rules. These facilities are therefore not required to have a WMP when in operation nor are they required to either develop a WMP or close their lagoons if production ceases.

If a lagoon is held under a WMP, it must continue to undergo annual inspections to assure compliance. Allowing lagoons to remain open therefore requires that the DWQ continue to inspect these units, indefinitely, for water quality violations. As of August 12, 1997, the ratio of the number of animal operations requiring inspection to the number of full time personnel at the DWQ for performing animal inspectors ranged from as high as 316:1 in the Fayetteville DWQ Region to as low as 94:1 in the Asheville DWQ Region. If current inspection requirements are retained, workloads placed on DWQ (and DSWC) inspectors may prevent thorough inspection of inactive lagoons, as more time is likely to be allocated to inspection of active lagoons.

The rise of intensive swine operations in the state has forced small operations to leave the industry because they can no longer compete in the market. These smaller operations are primarily those raising less than 100 hogs, Therefore, lagoons which are currently becoming inactive in the state are at facilities which are not permitted. Although larger permitted operations are remaining open at the present time, the number of inactive lagoons at these facilities may increase in the near future. The major factors which will contribute to when and how fast this may occur include: the nature of the plan the NCDA develops to phase out lagoons (per its directive from the 1997 NCGA); the type of new waste treatment technologies that are adopted; and the affect increasingly stringent regulations adopted by counties and the state have on existing operations.

Of the approximately 3,000 permitted swine operations, 102 are subject to mandated closure provisions which exist at the county level. These closure provisions are contained in ILO rules that were adopted by health boards in five counties. Procedural requirements for closing lagoons were included in the rules adopted by all of the health boards. Bonding measures to assure that these procedural requirements are met were included in the rules adopted by four of the health boards. The majority of existing

operations in two of the five counties with lagoon closure rules are excluded from closure requirements because of the ILO definitions used and the exemptions that are provided. These counties are Nash and Chatham. Of the 102 operations that are required to close under the adopted rules, 80 are in Columbus County, 20 are in Scotland County, one is in Chatham County, and one is in Nash County.

The threat or fear of lawsuits from the swine industry has prevented at least two health boards from adopting ILO rules - and therefore closure provisions. It is not known to what extent legal threats and other concerns, such as lack of available resources for implementing and enforcing rules, had in dissuading other health boards from adopting ILO rules.

Four ordinances containing moratoriums on new ILOs have been adopted by county commissions. These ordinances indicate a willingness at this level of government to exercise authority in regulating ILOs. Although Duplin County, the county with the highest hog population in the state, has adopted an ILO ordinance, it does not contain closure provisions. It therefore still remains uncertain whether heavily hog industrialized counties have the will or power to adopt such regulations.

Regardless of whether a lagoon at a permitted facility is closed under state or local provisions, the closure must comply with the Interim Standard developed by the NRCS. Lagoons closed at non-permitted facilities can only be encouraged to follow this standard, unless closure is funded through the NCACSP. In this event, compliance is required. The Interim Closure Standard was adopted by the NRCS in 1995 for use in North Carolina and will be considered for reauthorization in 1998. The Interim Standard requires that all wastes and input devices be removed from the lagoon and that wastes be disposed of according to accepted practices (i.e. land application at agronomic rates). If the structural integrity of the cleaned lagoon allows, it may be maintained as a freshwater pond. Otherwise, it must be filled with some type of inert material. Costs of closing a lagoon according to these standards will vary with several factors including, amount of sludge and liquid waste in the lagoon; consistency of the sludge, which affects whether the sludge material could be agitated and subsequently pumped from the lagoon or

whether excavation was needed; amount of land available for spraying and distance of land from the lagoon; amount of disturbed area to be revegetated; and availability of labor.

According to NCACSP records, costs of closing lagoons ranges from $5 to $32 per 1000 gallons of waste. A lagoon with a capacity of 100,000 cubic feet (748,052 gallons) would therefore cost between $3,740 and $23,937 to close under current NRCS standards. Although the present level of voluntary closures is not known, it is reasonable to conclude that at these costs, a high level of voluntary closure is not currently achieved nor is it likely to be reached in the future, as the majority of lagoons at registered facilities in the state range in size from 100,000 to 2,000,000 cubic feet. Significant levels of voluntary closures are also not to be expected if owners do not consider the risks of an unclosed lagoon and the liabilities of those risks to be substantial (e.g., violating water quality standards).

There are two sources of funds available for closing swine waste lagoon in North Carolina, apart from those provided by the owner. These funds include those of the NCACSP and the EQIP. Other states have recently taken steps, through legislative mandates, to assure that animal operations provide funding for cleaning their facilities when they become inoperative. Two mechanisms have been adopted and include a financial bonding requirement and creation of a "clean-up" fund. These funds are supported through either a one-time fee that is based on the amount of waste produced at a facility, or through a flat-fee based on the number of animals at the facility. A similar "clean-up" fund has been developed in North Carolina for USTs.

The practice of closing lagoons by land applying waste also has inherent risks. Runoff of land applied wastes will occur but will vary with method of land application (less when it is incorporated into the soil and more when it is spray irrigated). Risks posed to water quality, both surface and ground water, are of the same general nature as those associated with lagoons. Odors are also emitted during land application. Although the amount of odor will depend on application methods, they may have adverse impacts on humans in the vicinity.

Closing lagoons according to current NRCS standards will also require that land is available for this purpose. An assessment of the amount of land needed to close all swine lagoons in the state was not able to be completed. The vital missing pieces of information were total swine lagoon capacity in the state and composition of waste in existing lagoons was not available. Lagoon capacity was not available from the DWQ nor could it be accurately estimated because of insufficient information on number of different hog operations. Assumptions about the amount of sludge, nitrogen content of waste, and waste in the estimated lagoons could also not be accurately estimated in a manner which allowed credible estimates. However, a rough calculation was performed to get an estimate of the land needed to close a given swine waste lagoon volume according to NRCS Standards.

The computation performed was based on a ten percent reduction in the state's September 1997 swine population of ten million (NCDA 1997). The ten percent reduction was selected for two reasons. First, it provides a small enough reduction in swine populations that might reasonable occur in a short period of time. Second, it is an increment which allows the results of the computations to easily be calculated for additional population reductions of the percentage. Several assumptions had to made about the reduction of one million hogs in the state's hog population. These assumptions are that: 1) the reduction occurred at registered facilities, 2) waste from the hogs was treated and stored in anaerobic lagoons, and 3) hogs were from a farrow-to-finish operation. At a farrow-to-finish operation, one sow and 20 pigs are equal to one animal unit. Therefore, a reduction of one million hogs would equal 47,619 animal units (1,000,000 divided by 21). According to the NRCS Waste Utilization Standard (#633), each animal unit at these operations produces approximately 8,632 gallons of manure slurry (manure, urine, and excess water) per year (NRCS 1996). This manure slurry contains approximately 91 pounds of nitrogen (per animal unit) that is available for plant uptake when the waste is spray irrigated.

The following five conditions are also placed on the land application of the waste: 1) the waste is to be spray irrigated, 2) the crop being irrigated is Bermuda grass, 3) a

yield of six tons of Bermuda grass per acre is expected, 4) the limiting nutrient determining land application rates is nitrogen, and 5) the waste is applied as a slurry[26]. Based on these restrictions, the waste can be applied at 300 pounds per acre per year (NRCS 1996, Harry Gibson Personal Communication February 27, 1998). At this rate, the land that is needed to agronomically apply waste from a farrow-to-finish operation is .30 acres per animal unit (NRCS 1996). Assuming there was a six month accumulation of wastes from the hogs, 14,287 acres would be needed to land apply the waste (.30 acres per animal unit x 47,619 animal units). This is equivalent to 22 square miles (640 acres = 1 square mile). For reference, in 1995 there were over four million acres of harvested cropland, 862,000 of which were in the thirteen southern coastal counties of Bladen, Brunswick, Columbus, Cumberland, Duplin, Harnett, Hoke, New Hanover, Onslow, Pender, Robeson, Sampson, and Scotland (NCDA 1997) .

Several important points need to be made concerning the calculation. First, average numbers were used for concentration of nitrogen in the waste. Analysis of nitrogen content in wastes would be necessary to determine the correct agronomic rate for land application. This concentration and will depend on various factors including previous management, precipitation, and length of time waste has been stored. Second, soil nitrogen concentrations would also need to be analyzed when determining agronomic rates and soil conditions will affect the expected yield from any irrigated crop. Third, the calculation does not take into consideration sludge accumulation, which will vary with prior sludge removal practices. The amount of sludge in the slurry will affect the nitrogen and metal content of wastes. Fourth, the six month accumulation of wastes in lagoons does not take into account that lagoon capacities may be enable a greater volume of waste storage. Fifth, crops which do not utilize nitrogen as efficiently as Bermuda grass will increase the amount of land needed for land application. However, as Bermuda grass yields a product which has little economic value, choosing other crops may be

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[26] A slurry is a mixture of sludge and supernatant. This is typically the manner in which waste is land applied when lagoons are closed (Tim Etheridge Personal Communication February 27, 1998).

beneficial to the operation owner. Finally, although the amount of land needed for land application of these wastes appears to be relatively low when compared with the total amount of land in crop production, the end use of this land may be limited if irrigation results in excess levels of heavy metals, which will limit the end use of the land.

From the information presented in this paper, it is concluded that North Carolina should consider developing a plan which comprehensively addresses the issues related to closing inactive swine waste lagoons. A set of recommendations is offered below which identifies components which need to be considered for inclusion in a comprehensive plan. These suggestions recognize that the risks to the environment from both active and inactive lagoons have not been quantified and that there is even less information that identifies or quantifies the risks to posed to human health. Risks to human health will be heavily dependent on level of groundwater contamination, whether the water is used for consumption, and how susceptible the populations are to adverse impacts from high levels of nitrates. Because the paths of nitrates in groundwater are difficult to estimate, the contribution of nitrate levels from lagoons is also difficult to estimate

Over the past seven years regulatory agencies and the General Assembly have been absorbed with resolving problems associated with the use of anaerobic lagoons at intensive swine operations. Now is the time for the North Carolina General Assembly and state commissions to begin addressing the long-term swine waste management issue of closing inactive lagoons. It is clear that much uncertainty still exists with regard to risks posed by lagoons and that additional work is needed to formulate effective closure policies. Continuing to operate under current regulations based on the absence of scientific certainty may lead to consequences which do not serve the best interests of the citizens or protect the natural resources of the state, as may mandating closure according to current standards. The state therefore needs to begin identifying potential closure policies, developing a strategy to investigate the impacts of these policies, and building a coalition of supporters to assure that policies are implemented successfully. Actions for developing a closure plan should begin in the near future as it will require considerable

time and effort to design and adopt policies which are both equitable and effective. The fact that the swine industry is expanding into other regions of the nation, although not a clear indicator that the industry is migrating out of North Carolina, should be heeded as an action that alerts regulators to this possibility. If production does shift out of the state, financial resources for closing lagoons could be lost if mechanisms are not in place to hold current owners/operators accountable for closing costs. It is also imperative that the state take action because county governments may not have the resources available to adequately develop and enforce their own regulations. State action would also provide uniform regulations for the swine industry and prevent the need for local governments to act independently.

Closure Standards

The current closure standard of the NRCS needs to be evaluated for effectiveness and necessity of individual components. It is understood that there are risks associated with closing lagoons, namely risks to ground and surface waters caused by land applying sludge and supernatant. The issue of greatest concern is with sludge disposal. Lagoon sludge will have high concentrations of heavy metals, which if applied in excess amounts will effect soil conditions and their end use.

A comparison of all environmental risks produced for different closure options (e.g. sludge and supernatant removal versus only supernatant removal) could aid in developing a closure standard that considers risks of the entire closure process and therefore minimizes total environmental risk. Investigation of the closure standard should include researching methods to bioremediate lagoon liquids while they are in the lagoon. The necessity of removing sludge from a lagoon as a part of closure also needs to be investigated. Consideration should be given to alternative methods of sludge treatment/disposal. One option is to remove the supernatant but leave the sludge in the lagoon and stabilize the material either physically or chemically (William Meyer Personal Communication February 10, 1998). To physically immobilize the material

and prevent or reduce the migration of heavy metals and nutrients such as nitrogen from the impoundment, concrete might be added to the sludge left in an impoundment (William Meyer Personal Communication February 10, 1998). The stabilized material could then be covered with soil. Chemically reducing the solubility of metals contained in the sludge is also an option that should be investigated. For example, reducing copper to its sulfide form (cupric sulfide) would reduce the solubility from 2.5×10^{-10} to 5.0×10^{-22} (William Meyer Personal Communication February 10, 1998). Similarly, the solubility of zinc when reduced to its sulfide form would decreases in solubility from 2.0×10^{-10} to 1.0×10^{-22}. Another option of sludge disposal to investigate is incineration. With all of these options consideration must be given to technical and economic feasibility, and long term environmental effects.

A hierarchy of closure standards might also be developed that varies according to the level of risk presented by a lagoon. These standards could be developed as Interim Standards by the NRCS or by the SWCC with assistance from the DWQ so that risks to water quality are sufficiently addressed. The hierarchy might address risks posed by different lagoons sizes, method and time lagoons were constructed, and location relative to other lagoons and surface waters. The difficulty with developing this standard will be assessing and categorizing the degree of risks posed by different lagoons and identifying actions which will efficiently address the various levels of risks. However, as it would be effective in addressing the greatest risks, it would provide a tool for expending private and public funds in an efficient manner. Under a voluntary closure policy, a closure standard which is tailored to the risks posed by a lagoon might increase the number of closures, provided closure costs are reduced. Where possible, feasibility of converting cleaned lagoons into wildlife ponds or wetlands needs to be researched. Financial incentives such as tax deductions or financial assistance could be used to couple these components with the closure standard.

Linking New Waste Treatment Technologies with Closure

As new technologies are adopted, the academic community and regulatory agencies should look for opportunities that link these technologies with closing lagoons. Two of the issues that will affect how easily and if this coupling can occur are as follows: whether or not new technology adopted by the industry uses existing lagoons, and if new technologies can be used to treat waste from existing lagoons in an economical manner. A problem which might be encountered with linking lagoon closure with new technologies that produce value-added products is that sludge in existing lagoons may have concentrations of heavy metals which prohibit its use in the product.

One mechanism that may be used for linking closure requirements with new technologies is through conditions of a permit. When technically feasible, a permit could include a requirement that waste in existing lagoons be treated by new systems if the lagoon will no longer be used. When developing closure policies, consideration should be given to how it might dissuade new waste treatment technologies, which otherwise prove to be economically and environmentally sound, from being adopted by the industry.

Time Limit

If a mandated closure policy is adopted for registered facilities, a maximum time limit needs to be established for closing a lagoon after it is no longer used as a treatment unit. The primary factor associated with environmental risks that will need consideration are those associated with changes in the integrity of lagoon walls and lining. Other items to consider will include the possibility of reimplementing the system, either on behalf of the current owner or a new owner if attempts are made to sell the operation. The limits adopted by the local health boards in the state should be considered for a reasonable allowable time limits for both selling an operation and closing the lagoon. These limits range from 15 to 36 months.

A time limit for closing might be established by incorporating a time in which

closure must be completed in the NRCS Standard for Number 633 - Waste Utilization Plan. This standard has a "required specification" that requires facilities which cease to operate to develop and implement a closure plan for their lagoons. Currently the standard does not a time limit. However, whether this could be enforced or not is questionable as it is unclear if the NRCS standards are an enforceable component of the .0200 Rules.

Financial Assurity Mechanisms

The state should adopt some type of measure to assure that funds are provided by lagoon owners for closure. Absence of this kind of provision will continue to place a burden on the resources of the state, in particular those of the NCACSP. Action on this recommendation should be taken immediately and should address mechanisms for including integrators. At a minimum, there are two options for addressing this issue, which include bonding of an operation in an amount determined needed to close a lagoon according to adopted standards, or creation of an indemnity fund. Adoption of either of these mechanisms will require legislative action. Although a thorough analysis of the advantages and disadvantages of each option was beyond the scope of this research, some general considerations which must be taken into account are offered here.

One of the primary advantages of bonding is that it does not "tie up" funds of the owner. Another advantage is that it is equitable because funds are used only for closing the lagoon owned by the individual that is bonded. Bonding responsibilities would probably need to be delegated to the DWQ as it is the animal waste regulatory agency that is responsible for permitting and is likely to have more resources to draw upon for implementing this type requirement than would the DSWC. The major disadvantage of this alternative is that smaller operations may face difficulties in meeting this requirement. Insurance companies may not provide this type of coverage for small facilities. Another disadvantage is that funds may not be quickly available and in some instances could require legal action to obtain. Administrative costs would also likely be high with this option as time and staff will be required to secure and periodically update

bonding documents.

With indemnity funds, the advantages are that resources are readily available and various disbursement designs could be developed to meet the state's closure funding needs. Funds could be restricted to closure of lagoons owned by individuals that had paid into the fund or could be used for lagoons with high environmental risks. Monies from an indemnity fund could be distributed by the DSWC or the NCACSP. Fees could be attached to an operation's permit, be based either on a flat rate or lagoon capacity, and be collected at the time of one of the annual inspections.

Cost -Shared Closures

One of the biggest concerns with the use of the NCACSP monies for closing lagoons is whether it is an efficient use of the Program's funds. A long term goal for determining this would be to assess the relative benefit-cost ratios of protecting water resources for various BMPs. However, for the present, deference must continue to be given to the SWC Districts in evaluating, prioritizing, and funding their water quality protection needs. Funding should continue to be offered for closing abandoned lagoons which are causing water quality problems, but parameters need to be defined which clearly identify these situations. A definition for an abandoned lagoon also needs to be developed.

As current caps on funding may prevent some lagoons from being closed (e.g. if the owner does not have sufficient funds for closing the unit), consideration should be given to increasing funding caps for closure in cases where there is a clear threat to water quality. Funding should also be limited to closing smaller lagoons.

Closing Authority

Closure of the lagoon and adherence to closure standards should continue to be handled through the DSWC and the SWC Districts (with assistance from the NRCS), as

these agencies have the technical expertise required to implement the practice. If a legislative mandate is not adopted which requires closure of lagoons (above a specified capacity), then the EMC should be granted clear authority to include a closure requirement in an operation's permit.

Currently Unused Lagoons

The state should acknowledge the existence of currently unused lagoons and the risks they pose by developing policies, mainly consisting of incentives, to increase their closure. It is probable that there are inactive lagoons, which due to evaporation, decomposition, and seepage over the years, only have a small amount of sludge remaining in the impoundment. These lagoons likely pose relatively little risk to the environment and human health and therefore may not need to be closed. Other currently unused lagoons in the state fall into three general categories for purposes of developing closure requirements.

Category I - This category includes waste treatment systems, which will include lagoons and storage ponds, at facilities which served operations with fewer than 250 swine. According to the data reviewed, there have been at least 1500 facilities which have ceased to operate since 1993, most of which raised fewer than 100 swine. Closing the waste impoundments at these facilities should continue to occur on a case by case basis and cost-share or similar assistance should continue to be offered. Consideration should be given to developing additional incentives to increase closure such as use of a tax incentive for conversion of lagoons to freshwater ponds for wildlife purposes.

Category II - The unused lagoons in this category are a subgroup of the 450 operations that were removed from the DWQ registration list because they fell below the threshold number required for registration. It is estimated that 250 of these operations have gone out of business and therefore are not required to close their lagoon(s) or maintain them

under a WMP. The other 250 operations, although still in operation, are also exempt from maintaining their lagoon(s) under a WMP. As these are larger lagoons than in Category I, consideration should be given to locating and assessing the condition of these lagoons (location of these facilities is not known as the DWQ did not keep records for these facilities). Financial incentives for closing these units should be developed to increase closure rates and cost-share funds should be available for owners of these lagoons. Resources of an indemnity fund (if one were adopted) could also be used for closing these unit.

Category III - This category contains unused lagoons existing at registered facilities which are still in operation. These lagoons could be identified during inspections conducted by the DWQ or the DSWC. Cost share funds could be made available for closing these units. Potential risks of these and other lagoons to water resources in the region should include an assessment of the cumulative impacts from waste lagoons and closure practices and policies should be developed to reduce this risk to an acceptable level based on this appraisal.

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APPENDIX

Swine and Total Number of Animal Operations Registered with the North Carolina Department of Environment and Natural Resources on March 26,1997 in Each Division of Water Quality Region

MOORESVILLE REGION

	ANIMAL OPERATIONS	
COUNTY	*SWINE*	*ALL OPERATIONS*
Cabbarus	2	7
Catawba	1	10
Cleveland	2	9
Alexander	2	16
Gaston	0	11
Iredell	3	66
Lincoln	3	12
Rowan	3	28
Stanly	2	20
Mecklenberg	0	6
Union	35	47
TOTALS	**53**	**232**

APPENDIX (continued)

WILMINGTON REGION

	ANIMAL OPERATIONS	
COUNTY	*SWINE*	*ALL OPERATIONS*
Brunswick	19	20
Carteret	2	2
Columbus	80	81
Duplin	643	647
Onslow	67	68
Pender	78	79
TOTALS	**889**	**897**

APPENDIX (continued)

FAYETTEVILE REGION

	ANIMAL OPERATIONS	
COUNTY	*SWINE*	*ALL OPERATIONS*
Anson	22	26
Bladen	165	165
Cumberland	40	40
Harnett	16	17
Hoke	17	18
Moore	11	12
Montgomery	6	9
Richmond	13	14
Robeson	65	71
Sampson	546	549
Scotland	20	27
TOTALS	**921**	**948**

APPENDIX (continued)

ASHEVILLE REGION

	ANIMAL OPERATIONS	
COUNTY	*SWINE*	*ALL OPERATIONS*
Clay	0	5
Cherokeee	0	2
Avery	0	0
Caldwell	3	6
Burke	2	4
Yancey	0	0
Mitchell	0	0
Madiosn	0	5
Haywood	0	29
Jackson	0	1
Polk	0	0
Henderson	1	10
Graham	1	3
Buncombe	0	16
Transylvania	0	2
Rutherford	2	7
Swain	0	1
Macon	0	1
McDowell	0	2
TOTALS	**9**	**94**

APPENDIX (continued)

WINSTON-SALEM REGION

	ANIMAL OPERATIONS	
COUNTY	*SWINE*	*ALL OPERATIONS*
Ashe	2	3
Alleghany	0	18
Caswell	2	4
Guilford	6	19
Forsyth	1	3
Davie	3	16
Wilkes	0	15
Watauga	0	0
Stokes	1	14
Surry	6	18
Rockingham	3	9
Alamance	1	15
Yadkin	4	23
Davidson	7	20
Randolph	18	42
TOTALS	**54**	**219**

APPENDIX (continued)

WASHINGTON REGION

	ANIMAL OPERATIONS	
COUNTY	*SWINE*	*ALL OPERATIONS*
Bertie	17	17
Camden	3	3
Craven	35	37
Currituck	3	3
Greene	128	132
Hertford	8	9
Hyde	14	15
Pamlico	3	3
Pasquotank	5	5
Perquimans	29	30
Pitt	69	74
Jones	62	62
Lenoir	90	92
Martin	14	15
Wayne	166	167
Washington	23	25
Tyrell	14	14
Beaufort	40	41
Dare	0	0
Chowan	16	16
Gates	21	23
TOTALS	**760**	**783**

APPENDIX (continued)

RALEIGH REGION

	ANIMAL OPERATIONS	
COUNTY	*SWINE*	*ALL OPERATIONS*
Chatham	5	29
Durham	0	1
Edgecombe	41	47
Franklin	13	33
Granville	1	10
Halifax	24	33
Johnston	84	87
Lee	2	2
Nash	34	52
Northampton	45	51
Orange	6	40
Person	15	18
Vance	1	1
Wake	5	15
Warren	15	19
Wilson	24	24
TOTALS	**315**	**462**